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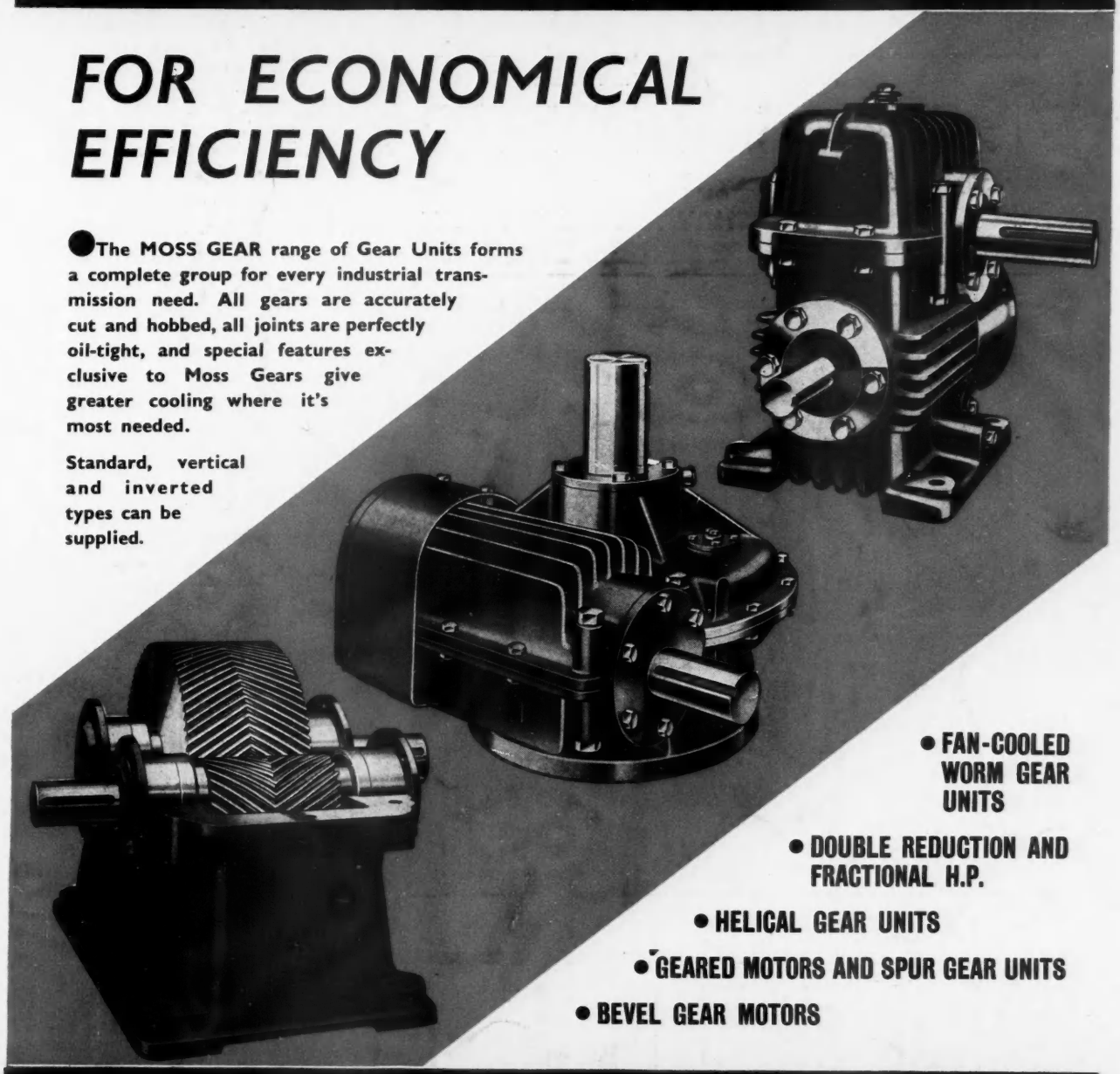

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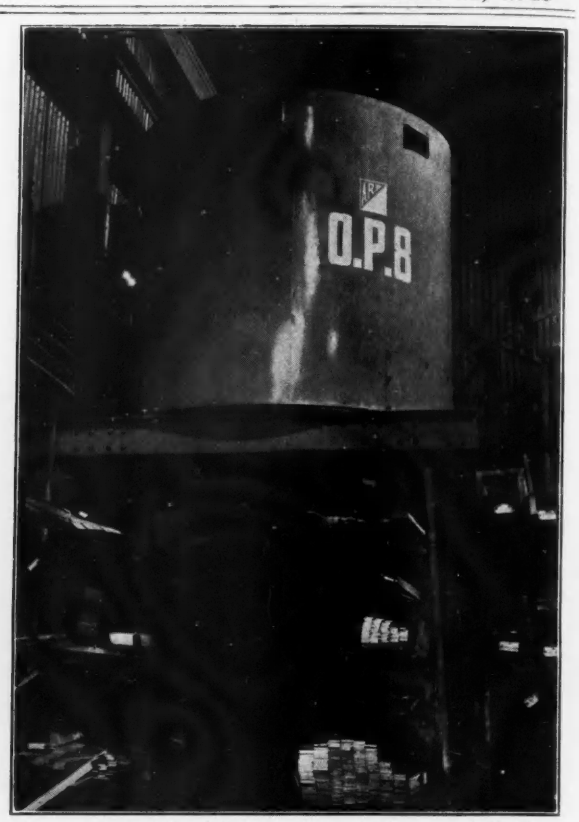

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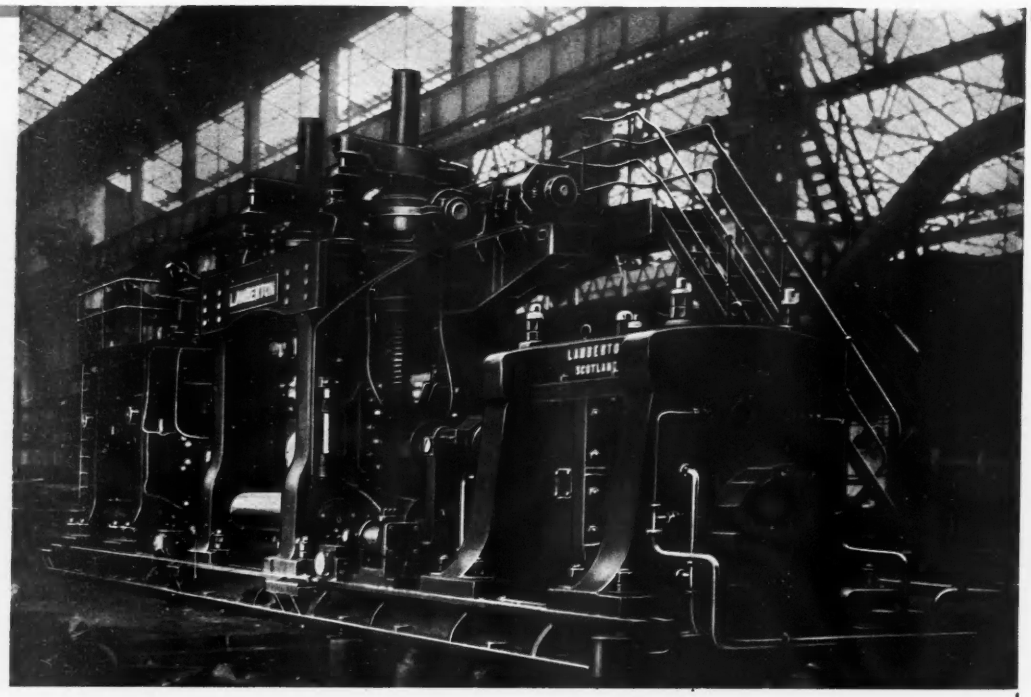

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The Superiority of British Aircraft

IN the course of his address broadcast on Saturday, February 10th, the Secretary of State for Air, Sir Kingsley Wood, dealt with the progress of the war, and more particularly the part played in that progress by the Royal Air Force. On the subject of the superiority of British aircraft, Sir Kingsley said that the least we could do for our airmen in carrying out their arduous tasks was to provide them with aircraft and equipment of the best. Our aircraft, he said, had now been in contact with most of the latest German types, but the number of engagements had, as we knew, been limited, and any conclusions which might be drawn from those engagements would be obviously provisional. War, it should be remembered, was full of surprises, but we could certainly claim that the war in the air had not only demonstrated the indomitable courage of British pilots, but it had also shown the definite technical superiority and power of many of our machines. Before the war much had been done by long and patient work in increasing the power and efficiency of our machines. The "Hurricane" and "Spitfire" to-day carried twice as many guns as their predecessors, while the policy of fitting our bombers with power-driven turrets had represented a revolution in the design of military aircraft. Our eight-gun fighters had aquitted themselves magnificently, and we believed them to be the best machines of their kind in the world. We could not and must not, Sir Kingsley went on to say, rest on what had been achieved. We must go on every day—as we were doing—perfecting present types and introducing others with even higher speed, longer range, and better armament. The war was being fought in the design departments, and on the drawing boards, as well as in factories and in the air. High quality had always been the policy of the British Air Ministry; it had certainly paid and we did not intend to forego it. Development and advance must continue to be our watchwords. Since the outbreak of war, we had been steadily increasing our strength and perfecting our air defence. New squadrons had been formed, and the improving and re-arming of others had been going on continuously. Alongside this work we had been able to give considerable assistance to our friends abroad.

Increase in Aircraft Production

CONTINUING his address, Sir Kingsley Wood said that he would like to thank that great army which was strenuously engaged in aircraft production. In the year the output of aircraft had been doubled in numbers. That doubling meant not a two-fold, but a manifold accretion of strength, because the new types, which were now passing out of the factories, showed a great advance both in fighting qualities, and in performance, over the types which were in production a year ago. In the field of our aircraft production the numbers already employed to-day were higher than in the peak of production during the last war. We should need, however, greater numbers during the next twelve months, for our aircraft production was planned on a vastly increased scale. Many new aircraft factories would shortly be coming into production, and there were many extensions to the present works. We were again extending very considerably our sub-contracting work. All these developments would mean much more labour, and the continuation of our progress in aircraft production would continue to depend to a very large extent on our success in the very vital matter of labour. We must therefore in every direction intensify our efforts. As a nation we were perhaps slow at first to move. But throughout our history our resolution and determination had not been dismayed but strengthened by the difficulties and dangers we had had to encounter. It will be the same in this great struggle. Let us therefore go forward with determination, endurance, and confidence until victory is won.

Higher Railway Wages

ON Friday, February 9th, it was officially announced that the offer of an increase in wages made on Thursday by the Railway Executive Committee, to the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Railway Clerks' Association had been accepted by the unions. It may be recorded that the first-named two unions each asked for 10s. a week extra, while the railway clerks asked for an extra £20 a year. Under the new offer, the following flat-rate additions are to be made to the conciliation staff which is covered by the national agreements. Men are to receive 4s. a week, and junior males 2s. a week, while women will receive 3s. a week and junior females 1s. 6d. per week. For clerical staff, stationmasters, and supervisory staff the increases will be £10 per year for men, £5 a year for junior males, and 3s. a week for women clerks, with 1s. 6d. a week for girl clerks. These additions are to be taken into consideration in calculating overtime, Sunday duty, and night duty payments, but they will not be included in the calculation of superannuation allowances or pensions. The advances will include the cost-of-living additions, which became payable on January 1st, and the cost-of-living sliding scale is to be suspended. The railway shopmen, it is stated, are covered by this announcement, but those grades of railway staff which are not covered by the national agreements will be considered separately. It has been pointed out by Mr. J. Marchbank, the general secretary of the National Union of Railwaymen, that the agreement with the railway companies has established the principle of a uniform increase of wages for all grades of railway workers because of the increase of the cost-of-living consequent on the war.

British Compressed Air Society

THE tenth annual report of the British Compressed Air Society was presented at the annual meeting, which was held in London on Tuesday, February 6th. It is of interest to record that all the original founders of the society were represented at the meeting. The death of Mr. Vincent Clarke, honorary secretary from the foundation of the society, took place early in the year, and is deeply regretted. That work has now been placed in the able hands of Mr. E. Lacy-Hulbert. The membership of the society, the report states, has increased, and it now includes all the principal manufacturers of British compressed air plant, covering the whole range of such equipment. The society, it is pointed out, is thus in a position to give expert opinion upon any subject relating to compressed air, and in this connection it is represented on various sub-committees of the British Standards Institution, including the testing of air compressors, specifications for rubber hose, air receiver fittings, small air receivers, and the welding of thin sheet metal. Draft specifications covering these subjects have already been issued and brought to the notice of members. The Department of Mines has been approached with regard to the proposed legislation, regulating the use of compressed air drills and tools in mines, and although this matter may be held over during the war, the society feels strongly that the question of exhaustive research in this field should receive the careful consideration of members. As regards the work for the Defence Forces, it is pointed out that in all three Services compressed air is a vital factor both in production and equipment. The new edition of Compressed Air Terms and Standards is shortly to be put into the hands of the printers, and the preparation of this long-awaited new edition owes much to the work of Mr. R. L. Quertier and Mr. E. Lacy-Hulbert. After the meeting a luncheon took place at the Trocadero Restaurant, which was particularly well attended, and replaced the usual annual dinner. The chair was taken by the president, Mr. C. W. Crawshaw, of the Bryan Donkin Company, Ltd., of Chesterfield, and the principal guest was Sir Herbert G. Williams, who proposed the toast of "The British Compressed Air Industry." Mr. Crawshaw in his reply referred to the happy relations of the society with the Department of Overseas Trade and the Ministry of Supply. Mr. Frank Hills, an immediate past-president of the society, proposed the toast of the guests, and Mr. D. A. Bremner, the director of the British Engineers' Association, responded.

Transandine Tunnel Opened for Motor Traffic

ACCORDING to a message received from *The Times* correspondent in Buenos Aires, the Transandine railway tunnel was opened to motor traffic between Argentina and Chile on Saturday, February 10th, after alterations to the tunnel itself had been made and special roads had been constructed to give access to the tunnel at each end. About a year ago, we may recall, the Argentine Government voted a large sum of money for the purchase from the Transandine Railway Company of the railway and tunnel over the Andes. Part of this sum was expended in reconstructing certain portions of the line which had been damaged by river flooding. The tunnel was completed in 1910, to the designs of Messrs. Livesay and Henderson, of London, and a full account of the undertaking is given in a paper which was read by the late Sir Brodie Henderson before the Institution of Civil Engineers in 1914. The tunnel crosses the summit of the Andes at a height of 10,521ft. and it has a diameter of 16ft. 5in. at the widest point, and a height of 19ft. 3in. The track is designed in such a way that it has been found possible to construct on the top of it a surface suitable for road transport. Arrangements are made to suspend the motor traffic during the hours when trains are running through the tunnel. A large task which faced the engineers was the planning and construction of the special roads giving access to the tunnel at either end. The opening of this tunnel to road traffic will increase by several months the period of the year in which it is possible to cross the Andes by motor car. The existing road through the Uspallata Pass is blocked by falls of snow for nearly nine months in the year. Further details of this interesting piece of work will be awaited with interest.

The London Power Company

AT the annual general meeting of the London Power Company held on February 9th, at Ergon House, Horseferry Road, Westminster, the chairman, Mr. George Balfour, explained that the accounts to be approved were of the usual form. Operating conditions were, however, far from normal for during the first half of the year, for maximum demand increased by nearly 2 per cent. whereas during the second half a decrease of over 21 per cent. was experienced. The decrease was attributable to the serious falling off in demand experienced by the constituent companies and owing to evacuation, blackout, &c., and resulted in sharply rising costs of production. During the latter part of the year costs rose steadily and in December were much heavier than in the earlier months. The new year was started with a heavy increase in costs compared with those of 1939, and it was to be assumed that the condition would continue and still further increases might be expected during the present year. The increased cost had to be borne by the London constituent companies, which would have to raise their charges to meet the increased cost of production and falling demand. On the outbreak of war it was decided to avoid new capital issues as far as possible, and while war conditions continued to provide for capital commitments by employing the proceeds of the sinking fund and meantime only redeem Debenture Stocks to the minimum extent to comply with the provisions of the trust deeds. It was believed that in this way it would be possible to finance the completion of the constructional works programme without resorting to very heavy borrowing.

Anglo-French Trade Talks

WITH the approval of His Majesty's Government and of the French Government, arrangements have been made for a meeting between British and French industrialists for the purpose of discussing economic and commercial questions of common interest. The Federation of British Industries has invited the Confédération Générale du Patronat Français to send a small delegation to London, and this invitation has been accepted. It will be the object of the meeting to discuss the views of the industries of both countries on the following points:—The means by which British and French industry can best co-operate during the war for the attainment of the common objective, and for the solution of any difficulties which may confront them; and means of collaboration by which after the war the industries of the two countries could jointly contribute to an orderly change-over from war to peace conditions and to the creation of a more sound and stable world economic system. If, as is confidently expected, it is found that there is agreement on points of principle, it will be the object of the meeting to encourage conversations between individual industries in the two countries, in order that practical effect may be given to the principles upon which agreement has been reached. The Federation of British Industries states that it welcomes this opportunity of showing its friendship towards French industry and of contributing towards a strengthening in the industrial field of the ties which unite the two countries.

The Late Mr. S. F. Edge

BY the death of Mr. S. F. Edge, which occurred at Eastbourne on Monday, February 12th, at the age of 71, British motor car and motor boat racing has lost a pioneer, who by his efforts did much to influence the design of motor cars both in this country and abroad. Selwyn Francis Edge was born at Concord, Sydney, New South Wales, in 1868, and came to England some three years later. He was educated for an Army career, but as a young man was attracted by the safety bicycle. He entered the cycle business in the early nineties, and became associated with the Dunlop pneumatic tyre, which was at that time in the hands of the du Cros family. It was in 1897 that he began to interest himself in motoring, and in the following year he purchased the Panhard and Levassor No. 8 car. With that car he was able to persuade the late Montague Napier to begin the manufacture of motor cars. From 1900 when the first 9 H.P. Napier car was built, until 1912 when he left the Napier firm, he did much by his successful racing feats to popularise the Napier car and the motor boat engine, and to improve the design and performance of high speed petrol engines. After his retirement he took up agricultural work in Sussex, and did not leave his country pursuits except for a short time in 1917 when he was appointed by the Ministry of Munitions to be Director of Agricultural Machinery.

E

The Draining of the Isere Valley at Grenoble

THE town of Grenoble lies in the flat, mountain-bounded plain through which the River Isère flows to its junction with the River Drac some three kilometres below the town. The east and south-east parts of the town (Fig. 1), as well as the lowlands extending from the left bank of the Isère to the foot of the mountain slope between Grenoble and Domène, are frequently submerged when the river is in flood. In order to permit of the drainage of these low-lying lands and the development of the town suburbs towards the east, the municipal authorities in 1935 decided to carry out the construction of a land-drainage conduit on the left bank of the river. The contract for the first section of this work, which was designed by Monsieur Haegelen, Ingénieur-en-Chef des Ponts et Chaussées, was let in 1935. It comprised only the down-stream part of the complete project and included a covered canal or conduit 1641 m. in length having its outfall to the River Isère at the Jongking quay on the river bank (Fig. 2). The work is of particular interest because of the nature of the ground in which the conduit has been made and the draining of the subsoil by means of pump-wells necessary in order to facilitate construction and to avoid damage to neighbouring structures.

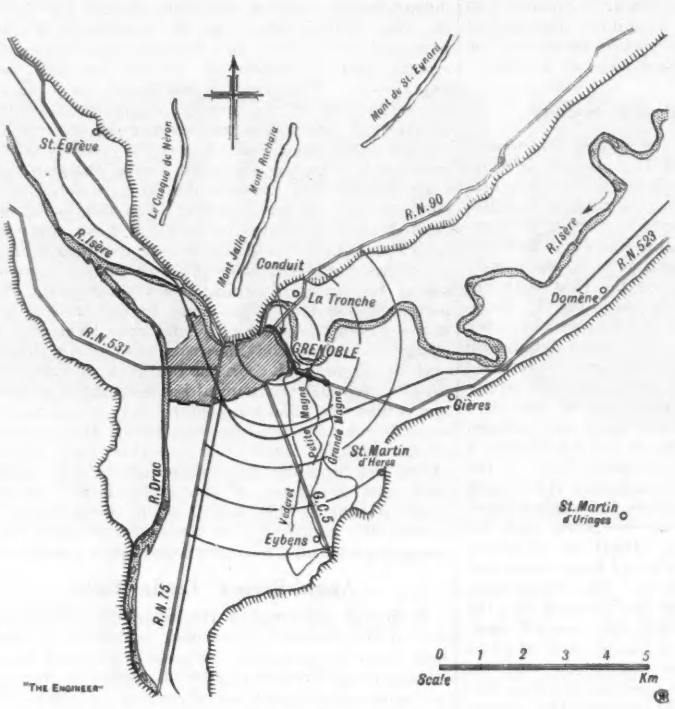

FIG. 1—SITE PLAN

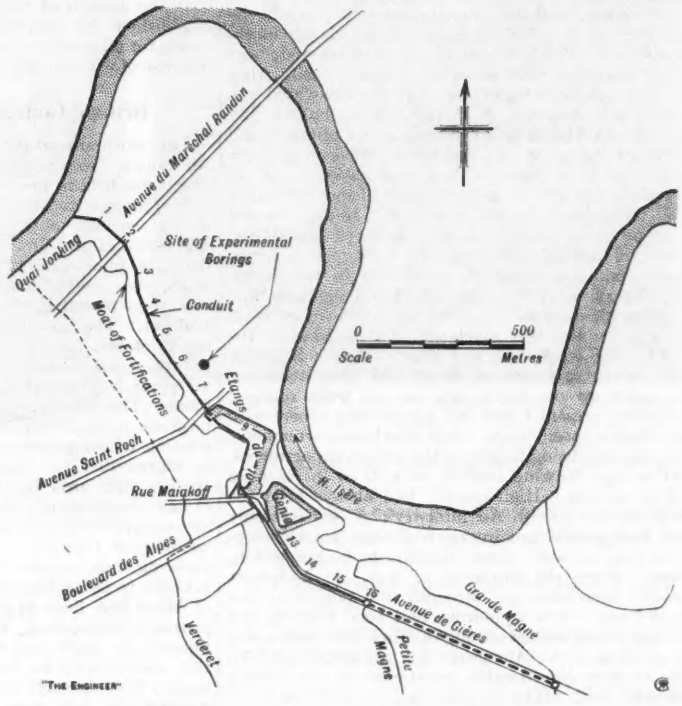

FIG. 2—GENERAL PLAN OF DRAINAGE CONDUIT

The canal, when it is completed as far as the village of Domène, will have a total length of 9300 metres. The down-stream section, about 1000 metres long from the junction with the Verderet stream to the river, comprises the covered canal of the section shown to the left of Fig. 3. This has a cross-sectional area of 8·22 m². The second section of the work already constructed, about 641 m. long, is smaller and is shown in section to the right of Fig. 3.

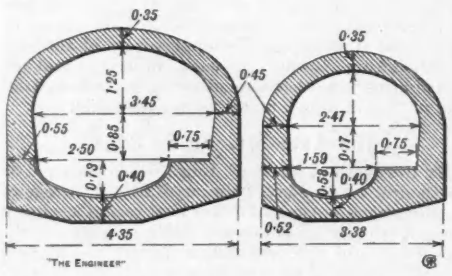

FIG. 3—CROSS SECTIONS OF COVERED CONDUIT

From the Jongking quay the conduit follows the line of the moat of the old fortifications crossing at two places parts of the moat still containing water known as the Etangs du Génie. The line proceeds thence in a south-easterly direction towards the village of Gières, crossing two streams, the Grande and Petite Magne, whose waters formerly discharged to the River Isère in the neighbourhood of the Etangs. The line of the work is shown by the trace in the photographic view (Fig. 9) and well sinking and earth dam building in the Etang in Fig. 12, p. 160.

The object of the canal is to collect and evacuate to the river the water from the moat of the fortifications and from the small streams which traverse

Investigation of Subsoil

The municipality in 1935 placed a contract for the construction of these works with a local contractor whose plan of operations provided for the construction of the conduit in short cofferdammed sections formed by driving Larssen steel piling to a depth of about 3 m., the soil within the lines of the piling being excavated in the ordinary way. It was, however, soon found that, beneath the surface soil, there existed beds of sand and gravel containing water which in places was under slight artesian pressure.

Attempts to de-water the cofferdams by ordinary pumping methods resulted in such considerable abstraction of sand from the adjacent ground that fissures occurred in the roadways and cracks appeared in neighbouring buildings. The contract work was, therefore, suspended while a series of borings was made and a further study of the subsoil conditions carried out. This investigation, made in August, 1936, included the sinking of fifteen exploratory borings and an investigation, by observations in a series of gauging wells, of the depression of the subsoil water table brought about by pumping from a well sunk for that purpose.

These borings, which were put down to a depth of about 10 m., disclosed a bed of muddy earth resting on a layer of blue clay beneath which are alluvial deposits comprising sands and gravels containing water under slightly artesian pressure. Pumping carried on continuously for seven days resulted in lowering the original water table in the vicinity of the well by 2·1 m. The results of this experimental pumping are shown graphically in Fig. 4. The water table was lowered by 0·5 m. at a distance of 10 m. from the pump well by continuous pumping at the rate of 7·5 litres per second. It was also found that variations of level of the River Isère affected the level of the water table with a lag of several hours.

Darcy's coefficient of permeability K deduced from the experimental data is 0·50 to $0·75 \times 10^{-3}$ m. per second. This value corresponds closely to the granulometric constitution of the material found in the neighbourhood of the well.

It is interesting to compare the value of K with the values determined for strata met with on other works where subsoil water has been lowered by pumping. The silty sands met with in driving the tunnel under the Scheldt and on the site of a recently constructed dry-dock at Antwerp have a value $K = 0·05 \times 10^{-3}$ m. per second; a similar value has been deduced for the strata on the site of the proposed sea-lock at Port Jérôme (Seine-Inférieure). Very fine sands excavated in making the barrage at Day in Tonkin and below the foundations of the large dry-dock constructed at Southampton, in 1932–33, have a value $K = 0·1 \times 10^{-3}$ m. per second, and for the fine sand at Dunkerque, where a sea-lock was made in 1935, $K = 0·2 \times 10^{-3}$. The tube-railway tunnel under the River Spree at Berlin was made in coarse sand having a value $K = 2$ to $2·5 \times 10^{-3}$.

The results obtained from the experiments at

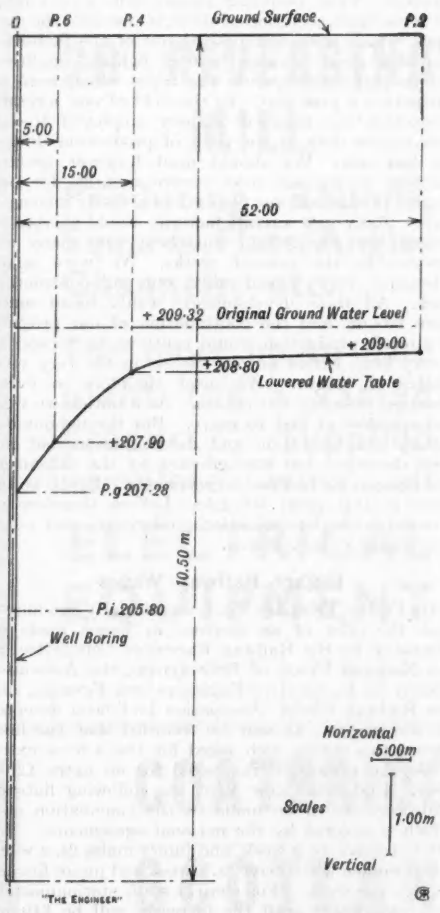

FIG. 4—DIAGRAM OF EXPERIMENTAL PUMPING

Grenoble demonstrated the practicability of lowering the subsoil water level to an extent which

would enable the conduit to be constructed throughout in the dry. Some minor alterations were made in the original alignment of the work and the level of the invert at the outfall to the River Isère was slightly raised and fixed at +207·3 m., the gradient in the lower section of the work being 0·4 per cent. and in the upper part 1 per cent. Fresh tenders were invited by the municipality for the execution of the work on the amended alignment and, towards the end of the year 1936 a contract was placed with Entreprises Industrielles et de Travaux Publics which proposed, in carrying out the work, to employ means of lowering the water table.

The contractors decided on a lay-out of the works which is shown diagrammatically in the longitudinal sections reproduced in Fig. 5. The arrangement of the pump wells and the lowering of the water table is shown in the typical diagram, Fig. 6. The capacity of the pumps required to effect the water lowering was calculated on the basis that a longitudinal section of the work 120 m. long would be under the influence of the pumping operations at any one time.

Duty of Pumping Plant

The calculation of the discharge from the several wells sunk in an area to be de-watered and of the spacing and capacity of the tubes is based on Darcy's formula. In the case of subsoils not under artesian pressure, that is when ordinary ground water only has to be dealt with, the formula may be expressed :—

$$Q = \frac{\pi K (H^2 - h^2)}{\text{Log}_e R = (1/N) \log_e (X_1, X_2, X_3, \&c.)}$$

Where Q = Quantity of water pumped in m³ per second.
K = Coefficient of permeability of the strata in metres per second.
H = Height of the original water table above the bottom of the well.
h = Height of the lowered water table above the bottom of the well at observation point.
R = Distance to end of cone of depression, or range of lowering, in metres.
X_1, X_2, &c. = Horizontal distances of pump wells from observation points.
N = Number of wells.

The experimental well pumping carried out on the site in 1936 indicated a local value K = 0·50 to $0{\cdot}75 \times 10^{-3}$. A value $K = 10^{-3}$ was, however, assumed as a safe figure for the subsoil in any part of the length of the work, 1641 m. Using this coefficient the value of Q deduced from the formula is 15–25 litres per second at lowest water-level in the river, 35–55 litres per second at mean water-level, and from 55–90 litres per second under high-water conditions in the river. The mean value for Q adopted for the work as a whole was 30 litres per second.

The total discharge Q can be realised in practice by means of N wells which may be assumed to be delivering equal quantities of water. A detailed study of the conditions showed that wells having a bored diameter of 500 mm. should be spaced from 12 m. to 60 m. apart according to the nature of the subsoil. It was finally determined to sink 100 wells, the spacing in general being 17 m.

Contractor's Plant Organisation

The work to be done comprised the excavation of approximately 400,000 m³ of soil and the placing of 10,000 m³ of concrete. In the downstream section of the culvert it was necessary to excavate 27 cubic metres of soil and to construct 6 cubic metres of concrete per lineal metre of the work. The general plan of the works having been determined, it became necessary to provide a plant equipment by means of which the work could be completed in a reasonable time without incurring an expenditure on plant out of proportion to the total value of the work. It was decided to employ plant which would ensure a theoretical progress of the work at the rate of 15 lineal metres a day. This involved about 400 cubic metres of earthwork and 90 cubic metres of concrete work, as well as the equipment of 15 lineal metres of the pumping installation, per working day. The plant was planned to commence operations at the downstream end of the line at the Quai Jongking, working thence towards the upstream end. The open, or partially opened, trench (Fig. 5) comprised a series of distinct but co-ordinated operations carried on concurrently over a length of about 240 m. The unit sections were 15 m. in length, being arranged so as to permit of the completion of each operation in a section in one day. Views of the work in progress are reproduced in Figs. 11 and 13 on page 160.

The sequence of operations was as follows :—

(*a*) Preliminary clearing of ground : removal of tree trunks, &c.
(*b*) Surface clearing and excavation to about 0·5 m. above the level of the extrados of the conduit.
(*c*) Sinking pump wells.
(*d*) Installation of pipe lines and commencement of pumping.
(*e*) Excavation to full depth in two unit sections.
(*f*) Poling and timbering in trench and levelling at bottom of excavation.
(*g*) Placing of concrete in invert, forms for the water channel (*cunette*) being placed simultaneously.

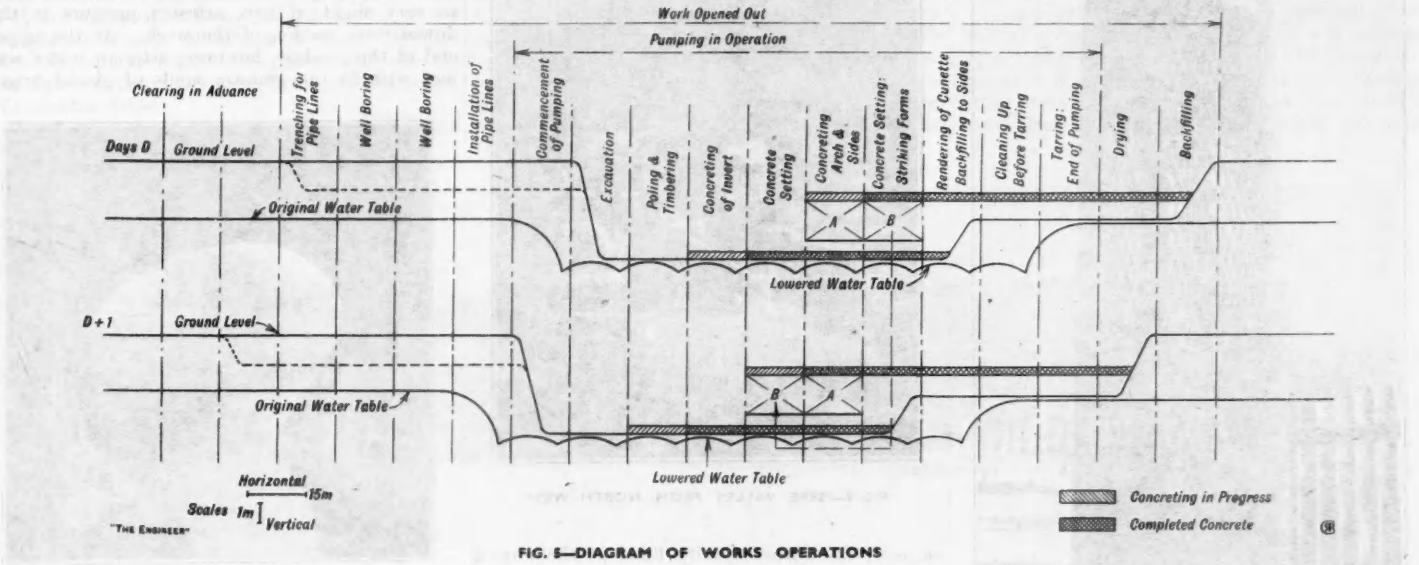

FIG. 5—DIAGRAM OF WORKS OPERATIONS

(*h*) Setting forms for the side walls and arch.
(*i*) Placing concrete in side walls and arch.
(*j*) Setting of concrete in arch.
(*k*) Striking forms for arch and moving forms forward to new position.
(*l*) Rendering surface of concrete in the *cunette* and cessation of pumping at the section.
(*m*) Tar-pitch coating of the concrete arch, &c., externally and dismantling of the pumping installation.
(*n*) Drying of the coating and drawing poling boards, if any remain in position.
(*o*) Back-filling excavation.
(*p*) Finishing and clearing up.

This organisation proved to be readily adaptable at points where the work had to be executed under or in contact with road crossings, streams, existing subsoil structures, and buildings, and where connection had to be made with the small waterways, such as the Verderet and Petite Magne streams, which discharge into the conduit.

Pumping

Several alternative means of well sinking were considered : it was found that the variable nature of the soil met with was not favourable to the employment of water-jetting and all the wells were, therefore, sunk by boring. The bore holes were 500 mm. diameter ; in these holes, tubes 280 mm. diameter were placed, the lower section, 5 m. to 7·5 m. long, being a perforated filter and the upper part unperforated. The annular space between the inner tube and the boring tube was filled with suitable filtering material. The perforated portion of the inner tube (Fig. 7) consisted of fine mesh expanded-metal surrounding a skeleton frame having screwed sleeves at the top and bottom ends. These tubes were found to be much superior to the perforated steel-plate tube covered with fine wire mesh hitherto generally used. It was found that the use of expanded-metal tubes avoided the reduction in efficiency due to electrolytic action resulting in a colloidal deposit between the perforations in the steel plate and the surface of the fine copper-wire mesh. Moreover the new form of filter does away with the necessity of refitting tubes for re-use with filter mesh, which is frequently damaged in the course of drawing the tube.

The wells were, in general, sunk to a level of 4 m. below the invert level, the top of the well tube being situated at a level a little above the extrados of the conduit (Fig. 6). The pump suctions were 100 mm. diameter, each being fitted with a non-return valve at its bottom end. At the upper end of each suction pipe was a stop valve, 100 mm. diameter, with a connection to the longitudinal

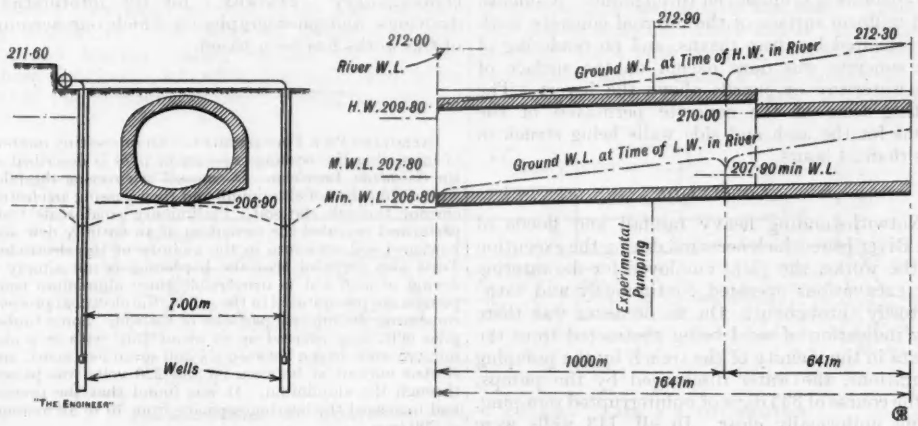

FIG. 6—DIAGRAM SHOWING LOWERING OF SUB-SOIL WATER LEVELS

collecting pipe, 200 mm. diameter, in which stop valves were placed at suitable intervals between the well points and the pumping station.

Each of the two pumping stations comprised two centrifugal pumps with belt drive from two separate electric motors, one stand-by internal-combustion engine being installed in addition. The normal procedure was to have one of the pumping stations working while the other was in course of being dismantled at the rear and

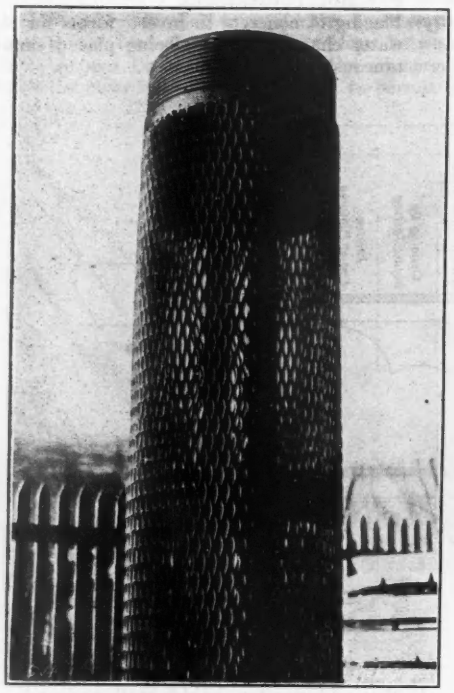

FIG. 7—EXPANDED METAL FILTER TUBE

moved forward ahead of the operating section. The pumps were of ordinary centrifugal type capable of maintaining a vacuum of 60–70 cm. of mercury in a pipe line, which was frequently 250 m. long, serving as many as 20 wells whose combined discharge was more than 150 litres per second. The suction head measured to the level of the pump shaft usually ranged from 6–7 m. and occasionally exceeded 7 m.

Earthwork

The trench excavation, carried out after the lowering of the water plane, was generally in alluvial material, part argillaceous and part gravelly. A longitudinal section on the line of the conduit is reproduced in Fig. 8. The de-watering of the subsoil made it possible to carry out the trench excavation by poling and timbering of much simpler construction than would have been necessary had the trench been dried out in the ordinary manner. Light steel trench linings of the "Union" type, 3 m. long, were employed at the sides of the excavation and held in position by runners and strut timbering of normal character.

Concrete Work

Concrete was gauged and mixed in a mobile concreting station which was moved forward as the work progressed. This unit included two mixers, one of 600 litres and the other of 800 litres capacity in which two categories of concrete were respectively mixed, that for the invert being gauged with 200 kgs. of cement to 400 litres of sand and 800 litres of gravel. The concrete in the upper part of the conduit has a dosage of 250 kgs. of cement per cubic metre of placed concrete. The concrete was brought to the place of deposit alongside the trench in trains of wagon

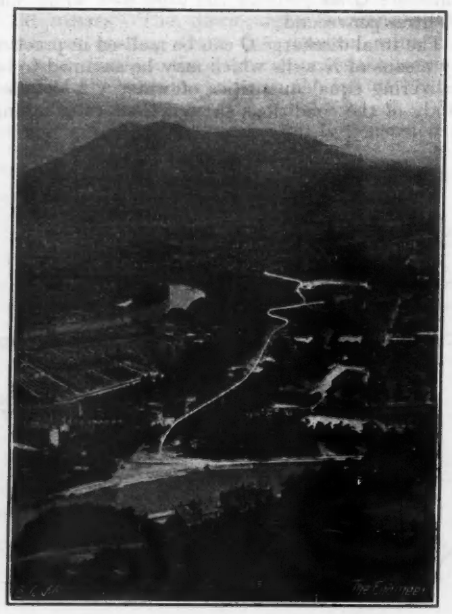

FIG. 9—ISERE VALLEY FROM NORTH-WEST

skips of 750 litres capacity filled at the mixing station. The trains were hauled by a 30 H.P. tractor on a 60 cm. gauge track laid along the side of the excavation or on trestlework.

The invert, with the *cunette*, having been concreted, the curved face of the latter being formed by means of steel shutters, steel forms, each 5 m. long, were placed in position to support the concrete in the side walls and arch. These collapsible and telescopic sections, three of which comprised one day unit, were mounted on wheeled carriages travelling on rails secured to ways which rested on the concrete of the invert. This arrangement secured regularity of the operations of placing and removing the forms. Pervibration of the concrete was employed throughout. A smooth and uniform surface of the internal concrete work was ensured by these means, and no rendering of the concrete was done except on the surface of the waterway or *cunette* above the invert. The setting time of the concrete permitted of the forms for the arch and side walls being struck in less than 24 hours.

Conclusion

Notwithstanding heavy rainfall and floods of the River Isère which occurred during the execution of the works, the plant employed for de-watering the excavations operated continuously and satisfactorily throughout. On no occasion was there any indication of sand being abstracted from the strata in the vicinity of the trench by the pumping operations, the water discharged by the pumps, in the course of 333 days of uninterrupted pumping, being uniformally clear. In all, 113 wells were sunk and the pumping installation occupied successively 8 separate stations. The total volume of water pumped was more than 2,000,000 cubic metres. It should be noted that the calculations based on, and the provisions made as a result of, the preliminary experiments proved to be amply sufficient when the lowering of the ground water came to be carried out. The information obtained from the advanced well borings as the work proceeded afforded all the indications required for the adjustment of details such as the spacing and depths of the bore holes still to be made.

Throughout the greater part of the work the subsoil water was normally ground water the level of which varied considerably with the level of the River Isère (Fig. 6). This ground water is subject to very slight, if any, artesian pressure in the downstream section of the work. At the upper end of the conduit, however, artesian water was met with in the granitic sands of glacial origin

FIG. 10—OUTLET OF CONDUIT TO RIVER ISERE

which underlie the clay bed. This artesian water rose to within 1 m. of the ground surface.

Fig. 10 is a view from the inside of the culvert at its outlet to the River Isère beneath the Quai Jongking, and in Fig. 14 on page 160 is reproduced a view of the junction of the short culvert, carrying the Verderet stream, and the main conduit.

We are indebted to Monsieur Haegelen for permission to publish this article, and to Lieut. Sautelet, now of the French Artillery and formerly the contractor's engineer on the work, and to our contemporary "Travaux" for the information, drawings, and photographs on which our account of the works has been based.

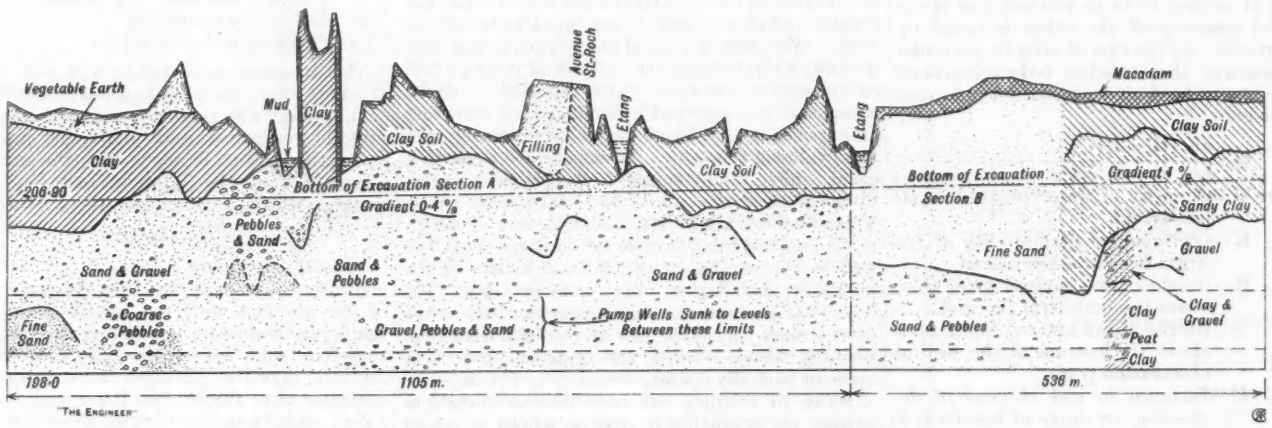

FIG. 8—GEOLOGICAL SECTION ON CENTRE LINE OF CONDUIT

Improving Pile Foundations.—An interesting method of increasing the bearing capacity of piles is described in the *Scientific American*. It consists of covering the piles with a thin sheetof aluminium and then passing an electric current through the soil. Preliminary small-scale tests performed revealed the formation of an entirely new and hardened soil structure in the vicinity of the electrodes. Tests also revealed that the hardening is not simply a drying of soil, but is irreversible since aluminium compounds are precipitated in the soil by the electrical process, cementing the mineral particles of the soil. Some timber piles 60ft. long covered up to about 25ft. with thin aluminium were driven between six and seven feet apart, and electric current at between 90 and 220 volts was passed through the aluminium. It was found that the process had increased the bearing capacity from 70 to an average of 200 tons.

Large American Mallet Locomotives

By HOWARD COBLE

No. II

(*Continued from page 130, Feb. 9th*)

NORTHERN PACIFIC RAILWAY.—CLASS Z–6 LOCOMOTIVE

FIGS. 5 and 6 represent one of the Northern Pacific Railway's (N.P.) colossal roller-bearing freight locomotives, having the 4–6–6–4 wheel classification. These Mallets, designated class Z–6, are operated in heavy freight service on the company's Rocky Mountain division between Missoula and Livingston, Montana, and also on the Pasco division between Pasco and Spokane, Washington State.

These engines, of which there are twenty-one in service, Nos. 5100 to 5120 inclusive, were built by the American Locomotive Company at Schenectady, N.Y., and delivered to the railroad during 1936–37. Whilst the first four completed, Nos. 5100 to 5103, have the usual friction bearings, the remaining seventeen, Nos. 5104 to 5120, are equipped with Timken roller bearings on the leading truck journals, the coupled axles, trailer, and tender trucks. They are the first steam freight locomotives in the United States so equipped.

From Table I, p. 127 (*ante*), and the diagram sheet, it will be gathered that the Z–6's are of very considerable proportions, standing 16ft. 11½in. high to the top of the smoke stack, and having a maximum width over running boards of 12ft. The total wheel base of the engine is 61ft. 10in., and for the complete locomotive 113ft. 8in.; over pulling faces of couplers the locomotive measures 127ft. 1½in. In full working order the locomotive weighs 463·9 tons (actually engines 5100–3 weigh slightly less than this figure); of this amount 278·6 tons represents the weight of the engine, with 194·1 tons available for adhesion. Turning now to the machinery, the cylinders (four) are 23in. in diameter by 32in. stroke, steam distribution being effected by 12in. diameter piston valves set to give a full gear cut off of 84·7 per cent., and operated by Walschaerts gear, which is controlled by an "A.L.C.O." type "G" power reverse. The maximum valve travel is 7½in., lead $\frac{5}{16}$in., steam lap $1\frac{1}{16}$in., and exhaust clearance $\frac{3}{8}$in.; the eccentric crank throw is 16½in. The driving wheels are of the spokeless "Boxpok" semi-disc type, 69in. in diameter, uniformly spaced at 6ft. 1in. centres, in each driving group. The tractive force at 85 per cent. of the boiler pressure is 104,500 lb. The factor of adhesion is 4·12 for the friction-bearing engines and 4·15 for those equipped with roller bearings. The boiler is of the straight-top type, having a designed working pressure of 250 lb. per square inch. The boiler barrel is made up of three courses of nickel steel, 98½in., 100½in., and 102in. outside diameters. The distance between tube-plates is 23ft., and there are 192 tubes of 2¼in. diameter and 73 5½in. diameter flues. A Worthington feed-water heater is fitted. It is of the type 6 S.A., supplemented by a Hancock type "W" injector. The firebox is of very large size, measuring 20ft. 6½in. in length by 9ft. 6¼in. in width, with a depth of 7ft. 6in. at the front, and 6ft. 6⅞in. at the back. A combustion chamber 7ft. 5in. long extends into the boiler barrel. There are three Nicholson's thermic syphons built into the firebox supporting the Gaine's arch. The firegrate measures 16ft. in length by 9ft. 6in. in width. It is of the Northern Pacific's round-hole table type. The grate, which has an area of 152·3 square feet, is fed by a mechanical stoker of the Dupont Simplex type, the engine of which is mounted on the left-hand side of the tender. It will be noticed that the grate area is larger than usual; that is due to the poor quality of the Rosebud coal used on this road. This coal is of sub-bituminous variety and as received from the mine has a heat value of only 8600 B.Th.U. per pound, and contains approximately 25 per cent. moisture and 8 per cent. ash. The Rosebud coalfields are the largest open strip mines in the world, and are owned and operated by the Northern Pacific Railway at Colstrip, Montana. They are estimated to contain upwards of 240,000,000 tons.

The tenders used with the class Z–6 are of the Semi-Vanderbilt type, mounted on two six-wheel Stucki side-bearings equalized trucks. The trucks have 37in. diameter wheels, with a wheel base of 10ft., and are spaced 27ft. 2in. between centres. The water capacity is 22,000 gallons and there is fuel space for 24·1 tons of coal. These tenders are among the largest so far built, with an overall length of 51ft. 7⅝in. and a maximum width of 10ft. 11 in. The loaded weight is 185·3 tons.

DYNAMOMETER TEST WITH CLASS Z–6 LOCOMOTIVE

During 1937 the mechanical department of the Northern Pacific spent several months in conducting a complete series of road tests with locomotive No. 5110 of the class Z–6. The complete dynamometer report covers in all 132 test runs made in heavy freight service over the Rocky Mountain division between Missoula and Livingston, Montana. To discuss this report in detail would be impossible within the limitations of available space, and attention must therefore be concentrated on the outstanding features. With this in mind the writer has selected for detail as representative of the best work performed data and results obtained on eight of the tests. Full details of the run selected are to be found in Table III. The table opens with test run AL–31, made on August 12th, between Livingston and Muir. Although the distance is only 12 miles, the line climbs 1048ft. After a glance at the gradient profile, Fig. 7 reproduced here, the formidable character of the climb will be more readily appreciated. After a preliminary 2 miles mostly inclined at 1 in 70–160 from Livingston, the ascent begins in earnest a short distance beyond mile post 117, and continues without intermission at 1 in 55 for 9½ miles, the final half-mile into Muir easing to 1 in 63. On the test detailed No. 5110, with a train of 66 cars, totalling 2518 tons gross, made the ascent non-stop in 50 minutes, at an average speed of 13·91 m.p.h. (Actually, the distance covered was 11½ miles, the run starting and finishing short of the terminal points.) During the climb, 5·5 tons of coal were fired, 1068 lb. per mile. The drawbar pull averaged 60,050 lb.,

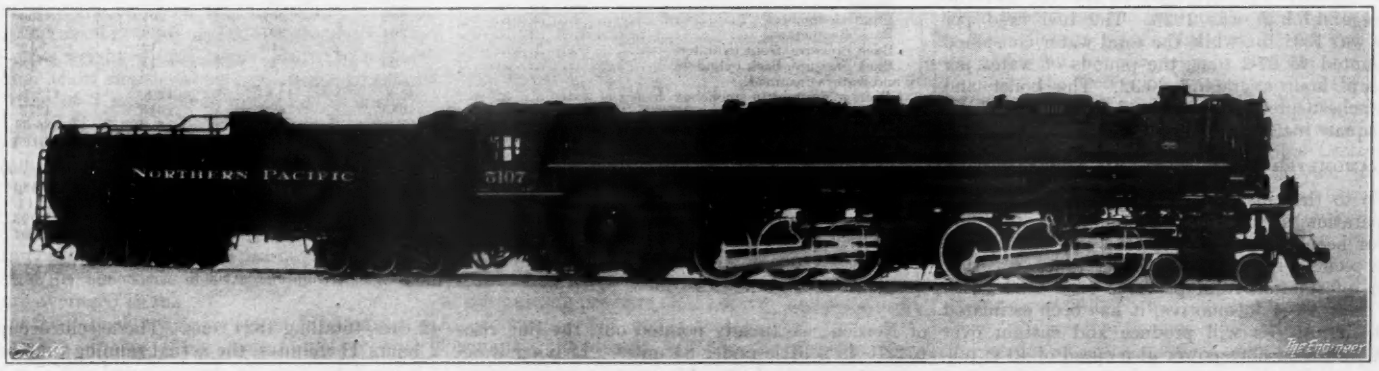

FIG 5—NORTHERN PACIFIC RAILWAY 4-6-6-4 CLASS Z-6 LOCOMOTIVE NO. 5107

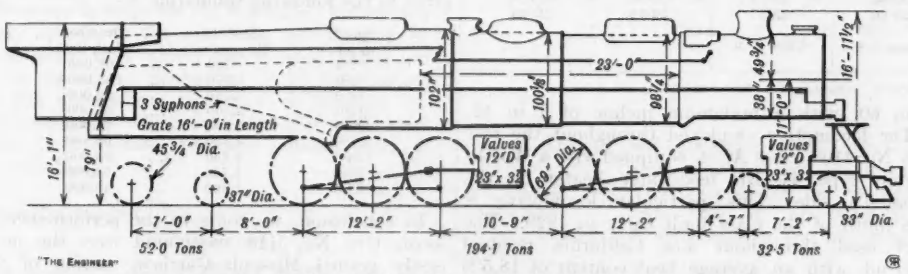

FIG. 6—DIAGRAM OF NORTHERN PACIFIC RAILWAY CLASS Z-6 LOCOMOTIVE

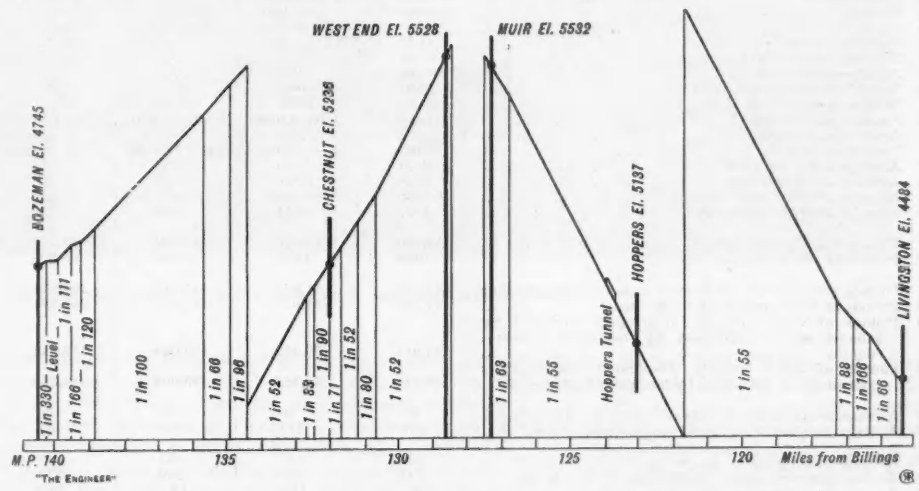

FIG. 7—PROFILE OF BOZEMAN—WEST END AND MUIR—LIVINGSTON SECTIONS

whilst the d.b.h.p. averaged 2227. The water consumed from the tender well totalled 21 tons, the pounds of water per d.b.h.p. hour being 25·43. From the table, it will be noted that the boiler pressure was maintained at 248 lb., whilst the pressure in the steamchest averaged 237 lb. per square inch.

Considering now the performance of No. 5110 eastbound between Bozeman and West End, the distance is a fraction under 12 miles, the line climbing 783ft. (see gradient profile, Fig. 7). Although not such a hard pull "against the collar" as the ascent from Livingston to Muir, the climb from Bozeman up to West End, 5528ft. above sea-level, is bad enough, averaging 1 in 80, with lengthy sections rated at 1 in 52, in particular the culminating 2 miles into West End. In all, seventeen tests were run over this route, eastbound, with various tonnage trains. The maximum load moved up the gradient was 80 cars, 3653 tons, on test A L–20, made on July 23rd. Details of this test are shown in the second column of the table. It will be seen that the ascent was made non-stop in 1 hour 5 minutes, at an average speed of 11·20 m.p.h. The drawbar pull averaged 64,400 lb. and the average d.b.h.p. was 1923. The fuel fired per mile was 1301 lb., while the total water consumed amounted to 27·2 tons, the pounds of water per d.b.h.p. hour averaging 29·32. The boiler and steamchest pressures averaged 247 and 236 lb. per square inch respectively.

Dynamometer Test with AC–4 Locomotive

Up to the time these notes were in course of preparation no thorough dynamometer test had so far been made with the class AC–7, but from data secured from speed-recorder tapes, together with information from previous tests made with the class AC–4 locomotive, it has been estimated that the AC–7's will produce and sustain over 6000 indicated horsepower at a speed of 40 m.p.h. However, in the absence of any complete test data for this class of locomotive, it is proposed to draw attention to the performance of the class AC–4 by setting out in some detail data obtained from a series of dynamometer tests conducted with this class of locomotive in the month of July, 1929.

Table III.—*Northern Pacific Railway. Comparative performance tests with various tonnage trains. Class Z–6 Locomotive Freight Service*

		AL–31	AL–20	Average of Five Tests	Max. Tonnage
1	Test designation	AL–31	AL–20		
2	Date, 1937	Aug. 12	July 23		Sept 19
3	Nozzle tip area, sq. in.	44·50	44·50	44·50	44·50
4	Train number	603	Extra	—	Extra
5	From	Livingston	Bozeman	Missoula	Missoula
6	To	Muir	West End	Garrison	Garrison
7	Distance, miles	11·59	12·13	69·37	69·08
8	Number cars—loaded	58	79	75	117
9	Number cars—total	66	80	78⅔	139
10	Weight of cars, loaded, tons	2316	3630	3532	5847
11	Weight of cars, total, tons	2518	3653	3607	6326
12	Actual time—running	50 min.	1 hr. 5 min.	2 hrs. 8¼ min.	3 hrs. 58 min.
13	Actual time—standing	—	—	—	30 min.
14	Total time on road	50 min.	1 hr. 5 min.	2 hrs. 8¼ min.	4 hrs. 28 min.
15	Average m.p.h. on road	13·91	11·20	32·32	15·46
16	Average m.p.h. running	13·91	11·20	32·32	17·41
17	Average drawbar pull—pounds	60,050	64,400	41,072	67,300
18	Average drawbar horsepower	2227	1923	3540	3125
19	Total pounds of coal burned	12,400	15,620	47,180	86,224
20	Pounds of coal fired—per mile	1068	1301	682	1249·6
21	Pounds of water from tender well, measurement—running	47,167	61,075	143,917	264,956
22	Pounds of water from tender well—total	47,167	61,075	143,917	267,356
23	Pounds of water actually evaporated—corrected for exhaust steam condensed by feedwater heater—running	55,011	70,352	170,009	312,948
24	Pounds of water actually evaporated—corrected for exhaust steam condensed by feedwater heater—total	55,011	70,352	170,009	315,348
25	Average temperature of feedwater from wayside tank, ° F.	67	60	58	56
26	Average temperature of feedwater entering boiler, ° F.	236	219	239	237
27	Average steam pressure, lb. per sq. in.	248	247	247	249
28	Average steam pressure—steamchest, lb. per sq. in.	237	236	230	232
29	Average back pressure—lb. per sq. in.	19·4	13·7	18·7	19·0
30	Average smoke box temperature, ° F.	633	608	638	631
31	Average temperature of steam at steamchest, ° F.	693	687	700	675
32	Average superheat in steam at steamchest, ° F.	292	287	302	276
33	Average temperature of exhaust steam at exhaust cavity, ° F.	368	377	343	368
34	Average superheat in exhaust steam at exhaust cavity, ° F.	114	135	91	116
35	Average draught in drum, inches of water	12·5	10·2	13·5	12·8
36	Average draught in firebox, inches of water	1·5	1·8	1·8	1·8
	Water performance based on items 21 and 22				
37	Pounds of water per D.B.H.P. hour—running	25·43	29·32	18·94	21·37
38	Pounds of water per D.B.H.P. hour—total	25·43	29·32	18·94	21·57
	Water performance based on items 23 and 24				
39	Pounds of water per D.B.H.P. hour—running	29·66	33·77	22·38	25·24
40	Pounds of water per D.B.H.P. hour—total	29·66	33·77	22·38	25·44
41	Type of helper locomotive used	Class Z–4	Class Z–4		

Although the AC–4 design dates back some nine years, these "Mallets" are almost identical in general dimensions and power to the AC–7's, see Table I (*ante*), except that the boiler working pressure is 235 lb. per square inch against 250 lb. in the later class; this results in a slight reduction in the weight on drivers and in the total weight of the engine, owing to the lighter boiler barrel. Also the tractive force is lower by some 7400 lb.

The dynamometer test was run eastbound over the Sacramento division between Roseville and Sparks, a total distance of 139·8 miles. The whole interest of the test naturally centres around the terrific climb from Roseville to the summit of Norden; as already pointed out, the line rises 6722ft. in a little under 84 miles. Leaving Roseville, the line climbs steadily up an average gradient of 1 in 80 for the first 35·3 miles to Colfax, 2417ft. above sea-level, with a maximum incline of 1 in 66. From Colfax up the final 51·3 miles to the summit level, 6884ft. above the sea, the gradient averages 1 in 60, with a maximum incline of 1 in 42.

The locomotive employed throughout the test was No. 4108, class AC–4, equipped with a Worthington type 4½ BL feed-water heater on the fireman's side. This particular locomotive is the ninth of the class built early in 1929. The fuel used throughout was California residual fuel oil, with an average heat content of 18,500 B.Th.U.s per pound.

Table IV.—*Southern Pacific Railway. Data and results for locomotive No. 4108 Class AC–4. Dynamometer test No. 7. Freight Service*

	Roseville to Colfax	Roseville to Colfax	Colfax to Summit	Roseville to Sparks
Location of test	Roseville to Colfax	Roseville to Colfax	Colfax to Summit	Roseville to Sparks
No. of test	Average 3.4.11	6	6	6
Date of test	July, 1929	July 19th, 1929	July 19th, 1929	July 19th, 1929
Distance. Time and speed				
Length of run, miles	35·3	35·3	51·3	139·8
Total time, hours, minutes	2 11	2 47	3 50	10 57
Running time, hours, minutes	2 0	2 13	2 59	8 25
Number of stops	1–3	2	2	17
Average speed, m.p.h.	17·7	15·9	17·2	16·6
Train data.				
Adjusted weight of train, tons**	1824	—	—	—
Number of cars in train	42	38	29	—
Number of loads	40·3	37	28	—
Average temperatures, deg. F.				
Temperature of water entering F.W.H.	77	77	74	*75
,, of water delivered to boiler	226	222	225	*224
,, of superheated steam in header	675	678	670	*674
,, in smokebox	563	571	563	*566
Average pressures, lb. per sq. in.				
Boiler	229	230	230	*230
Front steamchest	202	207	207	*206
Back steamchest	204	207	210	*210
Back pressure, front cylinders	15	13	12	*12
Back pressure, back cylinders	20	17	18	*18
Oil and water consumed.				
Average draught in smokebox, inches of water	13·8	12·6	12·8	*12·7
Oil fired, gallons	1685	1696	2316	4272
Oil fired, lb. per cubic foot of firebox volume per hour	6·96	6·31	6·40	*6·36
Water used from tender well, gallons	17,368	17,478	23,017	43,195
Results.				
Efficiency of boiler exclusive of feedwater heater	74·6	74·4	74·7	*74·5
Drawbar pull on level, lb.	70,370	71,570	69,140	*70,130
Drawbar horsepower on level	3316	3038	3171	*3114
Oil per D.B.H.P. hour, lb.	2·04	2·01	1·96	*1·98
Oil per 1000 U.S. Adj. ton miles, gallons	23·4	23·9	33·1	20·04

* Average of results on up grade. ** Adjusted to resistance of 80,000 lb. cars.

A study of Table IV, showing the data and results of the test, reveals the remarkable nature of the work performed. Consider first the data in Col. 1. The figures given are the average results of the three best runs (Nos. 3, 4 and 11) from Roseville up the 1 in 80 gradient to Colfax, a distance of 35·3 miles. The trains averaged 42 cars, totalling 1824 tons. The ascent occupied 2 hours 11 minutes, the actual running time being 2 hours flat, giving an average speed of 17·7 m.p.h. Excluding the feed-water heater, the boiler showed an average efficiency of 74·6 per cent. The oil fired amounted to 1685 gallons, oil per drawbar horsepower hour was 2·04 lb., and per cubit foot of firebox volume per hour, 6·96 lb. Water from the tender well totalled 17,368 gallons.

It should be mentioned here that on all test runs except No. 11 both exhaust nozzles were set at 6¼in. diameter; on run No. 11, however, the back nozzle was increased to 6¾in. diameter.

Cols. 2, 3, and 4 cover the data and results obtained on test run No. 6, on a continuous test from Roseville to Sparks, a distance of 139·8 miles. The load out of Roseville totalled 1788 tons, 39 cars; this train was worked up to Colfax in a net time of 2 hours 13 minutes, at an average speed of 15·9 m.p.h. The oil burned per drawbar horsepower hour the engine was working was 2·01 lb., and the water consumed totalled 17,478 gallons. At Colfax the load was reduced to 29 cars, 1,217 tons gross. With the train lighter by only 571 tons, the performance of No. 4108 up the ensuing 51·3 miles to the summit was particularly fine. The ascent occupied a total time of 3 hours 50 minutes, but the actual running time was only one minute under three hours, giving an average speed of 17·2 m.p.h. During the climb 2316 gallons of oil were fired, and water consumed from the tender well amounted to 23,017 gallons.

From the summit level down to Sparks the gradients are in favour of the eastbound traffic, and there is little of interest to record. The total time for the entire 139·8 miles from Roseville to Sparks was 10 hours 57 minutes, the running time being 8 hours 25 minutes, an average speed of 16·6 m.p.h. Stops numbered seventeen. For the whole trip oil fired totalled 4272 gallons, the oil per 892·8 adjusted ton miles was 20·04 gallons, and per drawbar horsepower hour 1·98 pounds. The total water consumed from the tender well was 43,195 gallons. The maximum d.b.h.p. and drawbar pull, equated to level line, recorded at speeds between 2·5 and 37·5 m.p.h. during these tests are given in the following tabulation:—

Speed. m.p.h.	Drawbar Horsepower	Drawbar Pull, lbs.
2·5	700	106,000
5·0	1,370	103,000
10·0	2,550	96,000
15·0	3,500	87,500
20·0	4,100	77,000
25·0	4,450	66,800
30·0	4,650	58,000
35·0	4,760	51,000
37·5	4,800	48,000

In conclusion, we come to the performance of locomotive No. 5110, eastbound over the more easily graded Missoula–Garrison section of the Mountain division. From Missoula to Garrison

the distance is 69 miles, the line rising 1048ft., at an average grade of 1 in 327, and is nowhere steeper than 1 in 250. Out of the total distance of 69 miles, only 3 miles are actually level, so that the gradient, although not so severe, is almost continuously against the eastbound traffic.

First let us consider the data set out in Col. 3. The figures given show the average results of five tests over this section with trains averaging 3607 tons. These tests were made between July 23rd and September 15th.

Possibly the most striking feature is the comparatively high average speed at which the tests were run; it will be seen that the average start-to-stop time was a little over 2 hours 8 minutes, equivalent to an average speed of 32·32 miles per hour.

The fuel fired amounted to 21·05 tons, averaging 682 lb. per mile. The total water consumed per trip averaged 64·2 tons. The average boiler and steamchest pressures were 247 and 230 lb., the temperature of the steam at the steamchest averaging 700° F. Finally we come to the magnificent performance on September 19th, detailed in Col. 4. The train on this occasion was made up to 139 cars, 117 loads and 22 empties, representing a gross weight of 6326 tons. No. 5110 worked this huge train unassisted up to Garrison in a running time of 3 hours 58 minutes, at an average speed of 17·41 m.p.h. The drawbar pull averaged 67,300 lb. and the d.b.h.p. 3125. As would naturally be expected coal consumption ran very high, averaging 1249·6 lb. per mile. A total of 119·3 tons of water was consumed, the pound of water per d.b.h.p. hour being 21·37. Throughout the run the boiler pressure averaged 249 lb., and that in the steamchest 232 lb. The back pressure averaged 19 lb.

From the data shown on representative indicator cards taken during these tests, together with material recorded by the dynamometer car, the following table has been prepared, showing the maximum i.h.p., d.b.h.p., and drawbar pull for several speeds ranging from 3·47 to 51 miles per hour.

Speed m.p.h.	Indicated Horsepower	Drawbar Horsepower	Drawbar Pull Lbs.
3·47	984	809	87,422
4·49	1278	1023	85,440
12·0	2954	2295	71,719
19·0	3680	2860	56,447
30·0	4398	3209	40,113
38·1	4566	3490	34,350
45·1	4678	3622	30,116
47·5	4814	3781	29,850
51·0	4610	3244	23,853

It will be seen that at 47·5 m.p.h. the i.h.p. reached a peak figure of 4814, 18 horsepower per tons of engine weight. In considering the relation of drawbar horsepower to indicated horsepower it may appear on the low side, but it must be remembered that these cards were taken on various ascending gradients. It is unfortunate that the necessary information to identify the conditions under which the individual cards were taken, *i.e.* test data, tonnage, location, etc., is not available.

SOUTHERN PACIFIC RAILWAY AC–7 AND AC–4 LOCOMOTIVES

For operating heavy freight traffic over the company's mountain territory in the west, between Roseville and Sparks, the Southern Pacific Railway (S.P.) uses very powerful articulated consolidated locomotives of the 4–8–8–2 type; they are known as the AC–7 class. On this section of the S.P. the route crosses the Sierra Nevada mountains at an altitude of 6884ft. above sea-level. As will be noted from the profile, Fig. 8, between Roseville and the Summit Station the heavy grade is almost continuous, the line climbing 6722ft. in under 84 miles.

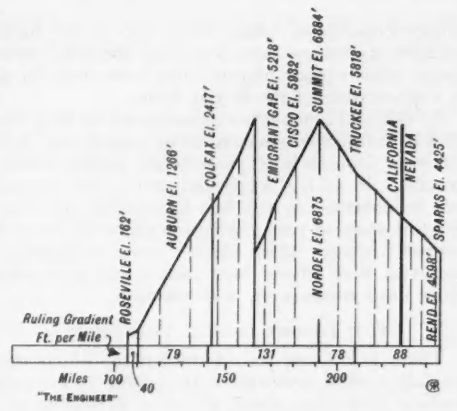

FIG. 8—PROFILE OF ROSEVILLE—SPARKS SECTION

The AC–7 class, see diagram, Figs. 9 and 10, are the largest and most powerful type in service on the S.P., with a rated tractive force at 85 per cent. of the working pressure of 124,300 lb. and weighing in working order 463·5 tons. The particular locomotive illustrated by Fig. 9 (showing the driver's side) is one of twelve similar engines built by the Baldwin Locomotive Works early in 1937. By the end of that year the railway had no less than seventy-one of these powerful units in service. In common with the earlier AC–4 class (built 1929), these engines run cab foremost, the engine unit being turned right round, with the smoke box facing the tender. As oil fuel has been adopted, this position raises no difficulties in the matter of firing, as the fuel is led along pipes to the burners. The enclosed cab arrangement gives the enginemen clear vision ahead, which is especially valuable when the locomotives are worked continuously at high rate on up gradients through tunnels and snowsheds in the mountain territory.

These locomotives are amongst the largest and most powerful so far built, and a few of the leading dimensions which give some idea of their size are as follows:—

Height to top of smoke stack	16ft. 4in.
Width over cab eaves	10 „ 0 „
Wheel base engine	67 „ 3 „
Length of engine, pulling face to chafing iron	79 „ 4 „
Total length over pulling faces of couplers	125 „ 5¼ „

In full working order ready for the road the AC–7's weigh 463·5 tons, the total weight of the engine alone amounting to 289·9 tons, of which 120·5 tons are borne by the leading (cab end) group of drivers, and 113·7 tons by the rear group, making a total of 234·2 tons available for adhesion.

The boiler is of the conical type, working at a pressure of 250 lb. per square inch. The boiler is built up in three courses. The first has a diameter of 94½in. and is 1 3/32in. thick, the second is 103 1/16in. diameter and 1½in. thick, whilst the third course is 1 5/32in. thick, with a maximum diameter of 106½in. There are 240 3½in.-diameter flues for an "Elesco" type "E" superheater, and 91 tubes of 2¼in. diameter, with a length of 22ft. The tube length is particularly short for a Mallet of such large proportions. A feed-water heater is fitted; it is of the Worthington open type, No. 6 S.A.

Acid firebox steel is used in the construction of the inside firebox with a thickness of ½in. for the tube-plate, ⅜in. for the wrapper, and ⅞in. for the door-plate; the firebox itself has a length of 196½in. by 102½in. in width and furnishes 513 square feet of heating surface. The grate area is 139 square feet.

The main frames are of the General Steel Castings Corp. cast-steel unit "engine bed" type, with cylinders, guide supports, cross-ties and several other parts all cast in one. The four cylinders, which have a diameter of 24in. and a piston stroke of 32in., have 11in. diameter valves, with a full gear travel of 6½in.; the lead is 3/16in. and steam lap 1 5/16in.

Electric-cast alloy steel is employed for the pistons, whilst other motion-work parts are of a high grade of carbon steel, normalised, and are designed for speeds up to 75 m.p.h. The driving wheels have a diameter of 63½in.; they are of the "Boxpok" thin-wall type. The main driving axle journals are 12in. by 15in., and those for the other coupled axles 11in. by 15in. long. The tenders used with the AC–7's are the largest on the S.P., running on two six-wheel Buckeye trucks; they have a capacity of 22,000 gallons of water, and 6,400 gallons of oil, and weigh fully loaded 173·6 tons.

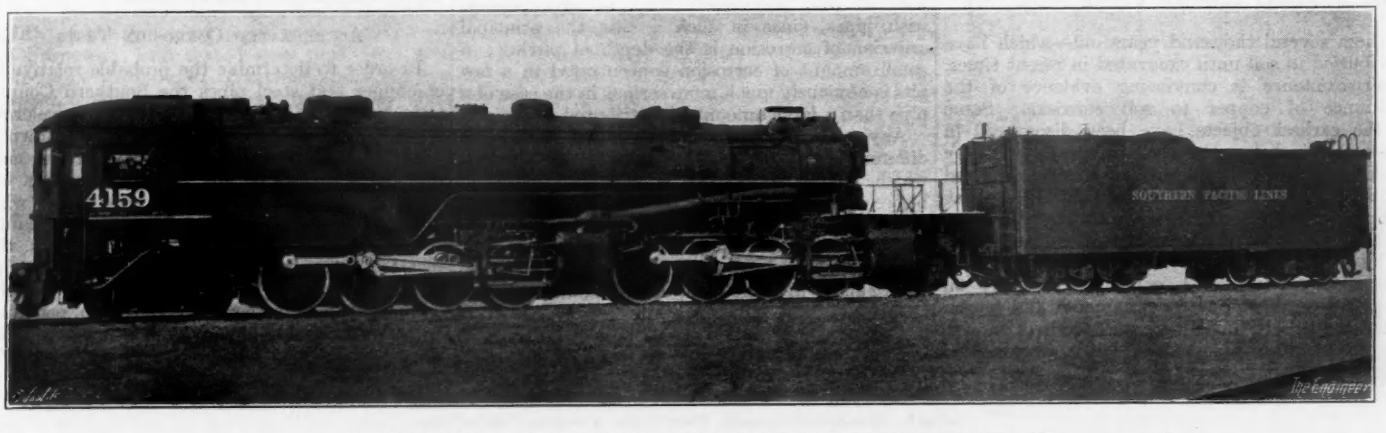

FIG. 9—SOUTHERN PACIFIC RAILWAY 4-8-8-2 CLASS AC-7 LOCOMOTIVE NO. 4159

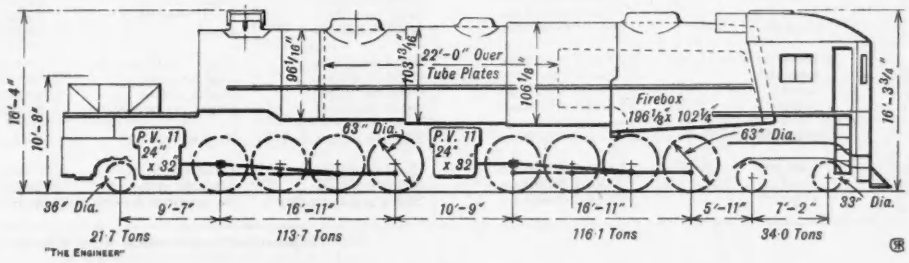

FIG. 10—DIAGRAM OF SOUTHERN PACIFIC RAILWAY CLASS AC-7 LOCOMOTIVE

In conclusion, the writer wishes to express his sincere thanks to Mr. A. B. Childs, mechanical engineer, Northern Pacific Railway; Mr. F. E. Russell, mechanical engineer, Southern Pacific Railway, and to Mr. W. B. Whitsitt, assistant chief of motive power and equipment, Baltimore and Ohio Railroad, for the material and data which form the basis of these notes.

The Resistance of Copper to Soil Corrosion

By H. G. TAYLOR, M.Sc.(Eng.), F.Inst.P.*

No. I

THE use of copper underground has developed considerably during the past twenty years for such purposes as buried earth electrodes and for gas and water pipes, although in this connection progress may have been somewhat retarded by the fear of corrosion. Experience, both in this country and abroad, has shown that this fear is generally unjustified, and evidence to this effect is given below in the form of operating records of a number of gas and water undertakings, and results of accelerated and normal corrosion tests conducted in many different soils.

Museums contain many copper objects—some

FIG. 1—ANCIENT EGYPTIAN COPPER WATER PIPE

of them several thousand years old—which have lain buried in soil until excavated in recent times. Their existence is convincing evidence of the resistance of copper to soil corrosion. Some of the earliest objects have been discovered in Mesopotamia below the level of the clay left by the Great Flood which is believed to have occurred about 4000 B.C. Very old copper objects thought to date from 4500 B.C. or even earlier have been found in graves of the Badarian type in the Fayum in Egypt.

The Egyptians used copper extensively in architecture as well as for ornaments and household utensils. Temple doors were made of copper, and even water pipes. The latter were folded from sheets into short tubes which were then joined together by inserting their ends one into the other. The completed pipe after being laid in a rock trench and covered with gypsum proved so durable that sections over 4000 years old are in existence to-day. One example, shown in Fig. 1, was used in the temple of King Sa-hu-Rē at Abusir, and is now in the Berlin State Museum. The thickness of the metal is 0·05in. and the overlap of the longitudinal joint about 1in. Crude copper implements which may date as far back as 2500 B.C. have been found in Ireland, while many other copper objects have been discovered in various parts of the British Isles.

All this and much other evidence serves to prove that in favourable circumstances copper may last for even thousands of years when buried underground. It is not suggested that such results can be obtained in any but favourable soils, but the fine state of preservation of the many buried copper objects which have been unearthed,† indicates that among base metals copper stands alone in its resistance to soil corrosion.

The Theory of Soil Corrosion

There is no one soil characteristic which can be taken as a measure of its power to corrode metals. Features which all have a bearing are the hydrogen ion concentration, the amount of moisture, the total acidity or alkalinity, the nature and concentration of the salts present, the grain size, the aeration of the soil and its electrical resistivity. Many attempts have been made to correlate one or other of these factors with the corrosion as measured by loss of weight or depth of pit, but whilst success has been achieved in particular cases, no general rules have been developed which are reliable for all soils. It is known, however, that a low electrical resistivity, a high acidity or alkalinity, or a high moisture content are conducive to corrosion.

Differential aeration of soil is an important cause of corrosion with ferrous materials, but is of less importance with copper, the corrosion of which, when it occurs, is, in general, more uniform than that of iron and steel. This is advantageous with pipes, since in such a case the principal criterion of corrosion is the depth of pitting; a small amount of corrosion concentrated in a few pits is obviously much more serious in the case of a pipe than a large amount of distributed corrosion.

Any conditions, such as contact with two different types of soil or contact with cinders, which set up differences of electrical potential between any two points on the surface of the metal, give rise to corrosion. Copper, like other metals, is susceptible to sulphide corrosion which may arise from cinders, from decaying vegetation (particularly in a salty soil) or from sewage.

Soil Corrosion Testing

There are three possible ways of securing corrosion data: (*a*) from records of actual experience, (*b*) from laboratory tests in which metals are buried in soils under normal conditions or under conditions whereby corrosion is accelerated, and (*c*) from field tests.

Actual experience in the resistance of copper to soil corrosion is provided by the historical evidence referred to in the introduction, and by extensive data secured in recent years by gas and water undertakings in various parts of the world. This evidence is given in later sections. In accelerated corrosion tests metals are maintained in contact with soil at a temperature higher than normal, and in the presence of oxygen under pressure.

The third form of test for corrosion referred to above is that of burying specimens in the field. The most comprehensive tests of this type are those of the Bureau of Standards in the United States. Tests on a smaller scale are now in progress in England, but results are not yet available.

The general conclusions reached from the Bureau of Standards tests are as follows‡:—

(1) Soils differ greatly in corrosiveness.
(2) Rates of corrosion differ with period of exposure.
(3) The depth of the deepest pit on a corroded area is a function of the area exposed.
(4) The relative corrodibility of different metals varies according to the type of soil.
(5) There is no close relation between rates of corrosion based on losses of weight and those calculated from depth of pit.
(6) Under apparently uniform soil conditions, the rates of corrosion of two specimens of the same material may differ widely.

These conclusions have led to the preparation of a list of requirements which are essential for a reliable field corrosion test. The only one of these which has special application to copper alloys suggests that tests for loss of strength should be made in the case of materials such as yellow brass, since the corrosion products are to some extent retained within the pits, and dezincification materially reduces the strength without always being obvious on visual inspection.

Some interesting qualitative data, which is given in Table 1, has been secured by the Manchester Corporation Waterworks Department. From this it will be seen that in no case, except when the soil was composed of cinders, was there more than a green coating on the copper, whereas other metals were, in all soils, at least slightly pitted, and in some cases in bad condition.

Accelerated Corrosion Tests

In order to determine the probable relative life of copper and steel pipes the Southern Counties Gas Co. of California conducted accelerated corrosion tests using the apparatus shown in Fig. 2. A weighed tubular sample of the metal under test measuring ¾in. diameter by 2½in. long by 18 S.W.G. was placed in a glass bottle which was then filled with a thoroughly moistened sample of the soil under test. The bottle was then inserted in a steel container shown on the right in the diagram. A number of these were then connected to an oxygen supply at 60 lb. per square inch pressure, and immersed in a hot water bath maintained at a temperature of 160 deg. Fah. Oxygen was allowed to leak slowly from the apparatus. These conditions of high temperature and high oxygen concentration are conducive to corrosion, which takes place at a greatly accelerated rate.

The results of one set of tests in which the materials were exposed to corrosion for six days are shown in Table 2, and photographs of some of the samples are shown in Fig. 3. The two soils

TABLE I.—*Manchester Corporation Water Works. Corrosion Tests on Pipes*

Type of Ground	Material	Time after installation of specimens					
		1½ years	2½ years	3 years	4 years	5¾ years	8¼ years
Cinders ...	Steel, hessian bound ...	Good condition	Good condition	Slightly pitted	As previous report	Hessian rotting badly	Hessian rotting, slight pitting on pipe.
	Cast iron	Coating slightly pitted	Badly pitted and cinders clinging to pipe	As previous report	As previous report	Very bad condition	As previous report.
	Lead	Slightly pitted	Slightly pitted	Slight pitting	As previous report	Slightly worse	Pitting extending.
	Copper	Slight green coating	Slight green coating	As previous report	As previous report	As previous report	Heavy green coating. Metal very thin.
Soil	Steel, hessian bound ...	Good condition	Good condition	Good condition	Good condition	Attack on hessian	Hessian rotting badly.
	Cast iron	Good condition	Good condition	Slight pitting	As previous report	As previous report	As previous report.
	Lead	Good condition	Good condition	Good condition	As previous report	Slightly pitted	As previous report.
	Copper	Good condition	Good condition	Good condition	Slight green coating	Heavy green coating	As previous report.
Sand	Steel, hessian bound ...	Good condition	Good condition	Good condition	As previous report	Slight pitting	Hessian rotted through.
	Cast iron	Good condition	Good condition	Slight pitting	As previous report	As previous report	As previous report.
	Lead	Good condition	Good condition	Slight pitting	As previous report	As previous report	Extensive pitting.
	Copper	Good condition	Good condition	Slight green coating	As previous report	Heavy green coating	As previous report.
Clay ...	Steel, hessian bound ...	Good condition	Slightly pitted	Slightly pitted	As previous report	Badly marked	Hessian rotted and pipe pitted.
	Cast iron	Good condition	Good condition	Good condition	Good condition	Good condition	Slight pitting.
	Lead	Good condition	Slightly pitted	Slightly pitted	As previous report	As previous report.	Deep pitting.
	Copper	Good condition	Slight green coating	As previous report	As previous report	As previous report	Heavy green coating.

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* Copper Development Association.

† Those interested in this aspect of the subject should refer to Copper Development Association publication No. 3: "Copper through the Ages."

‡ "Symposium on Corrosion Testing."—A.S.T.M., 1937, page 101.

used for this particular test represent extremes of corrosive types. Bare 3in. steel pipe is known by experience to have a life of about four years in Saticoy soil, and more than 20 years in Whittier Boulevard soil. Several interesting deductions may be made from these results as follows :—

(1) The corrosion of steel expressed as loss of weight is from 13 to 30 times greater than that of copper.
(2) The corrosion of steel expressed as maximum pit depth is from 74 to 250 times greater than that of copper.
(3) By deduction from (1) and (2) above, the corrosion of copper is not only less, but is much more uniform than that of steel.

During the later part of 1927 the company reports[7] § that it became necessary to rebuild nearly all the gas distribution system in the town of Saticoy on account of leakage, and from 300 to 1000ft. of the following pipes were installed for test purposes; lead coated steel pipe, steel pipe protected with one coat of asphalt and a rag felt wrapper, copper pipe and cast iron pipe. Just over four years after the installation it was necessary to replace the whole of the lead coated steel pipe and the wrapped steel pipe on account of corrosion. The cast iron pipe was severely graphitised in places, but still had a number of years of useful life. The copper pipe was in excellent condition.

During 1937 this company reported[14] that they had "over 100 miles of copper pipe installed in almost every type of corrosive soil to be found in Southern California. . . ." Some of this copper had been in the ground for nearly nine years without showing any signs of deterioration, whereas previous experience had shown that ferrous pipes, even when protected with asphalt, had failed in considerably less than this time in the same soils.

BUREAU OF STANDARDS FIELD TESTS

The Bureau of Standards soil corrosion investigations grew from a study commenced in 1911 on stray current electrolysis. This work involved the inspection of many underground structures, and it was frequently found that the amount of corrosion could not be related to that anticipated from the stray currents known to be flowing. These conditions led to an investigation being commenced on the direct soil attack on metals. As the work was related to pipe lines the materials for test were selected from stock and included various kinds and grades of pipes ordinarily available to the public utility companies. These stock materials necessarily varied in size and composition, and this consequently made the interpretation of the results somewhat difficult.

§ A bibliography is appended to the second part of this article.

From 80 to 100 different items were buried in 47 different soils. In the majority of cases more than one specimen was buried to provide a check, and to enable examination to be made after various intervals of time. In all about 15,000 specimens were buried over a period of years, and many of these have now been unearthed and their corrosion determined by measurement of the loss of weight and depth of pitting.

TABLE III.—*Comparison of Maximum Rate of Penetration in mils per Year for Various Loam Soils*

Copper	1·5	1·3	1·1	1·5	1·9	1·0
Ferrous materials	7·5	8·2	5·5	5·2	5·6	7·7

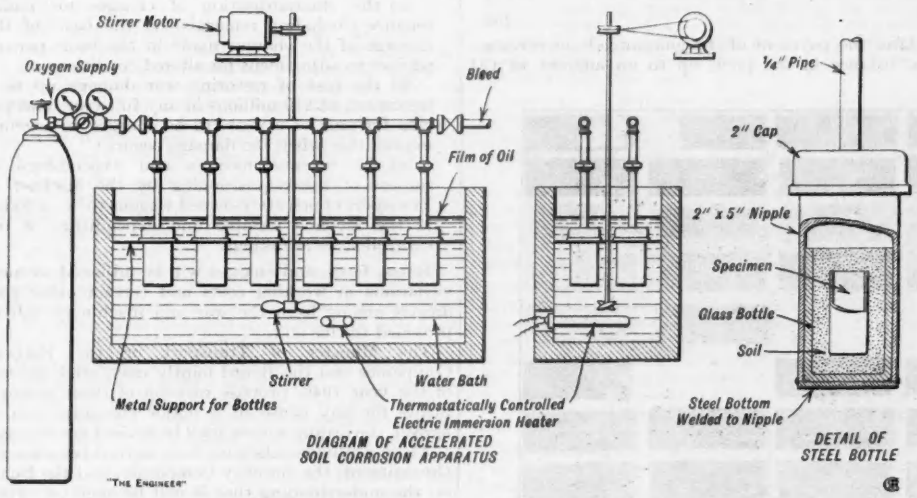


FIG. 2—ACCELERATED SOIL CORROSION APPARATUS

Since the purpose of the investigation was to determine whether corrosion might occur on pipe lines in the absence of stray electric currents, soils were chosen in areas where extensive pipe line systems existed and sites were selected which were free from stray electric currents. All the soils were carefully examined and classified and a very detailed record of their characteristics was made available.[2] The soils varied in electrical resistivity from 60 ohm-cms. to 800,000 ohm-cms.

Thirty-one different cuprous materials were tested, varying from copper of 99·97 per cent. purity to Muntz metal having 60 per cent. copper and 40 per cent. zinc, and a nickel brass having only 47 per cent. copper. The majority of these materials were in the form of pipe from 12in. to 17in. long and having a diameter usually between 1in. and 2in. The results for copper in comparison with wrought iron and steel for thirty-one soils are shown diagramatically in Fig. 4. These materials had all been buried for a period of from 8 to 12 years. Taking an average of all the results, the corrosion of the ferrous materials is 15·6 times that of the copper specimens; in six cases of the thirty-one it was over 30 times that of the copper, and in one case as high as 52 times. In very few cases was the rate of corrosion of the ferrous specimen less than four times that of the copper ones—an exception was soil 29 which was a tidal marsh, and in this soil Muntz metal was

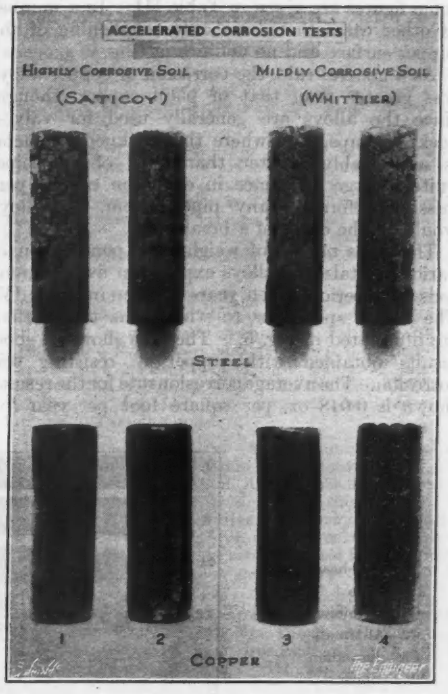


FIG. 3—ACCELERATED CORROSION TEST PIECES

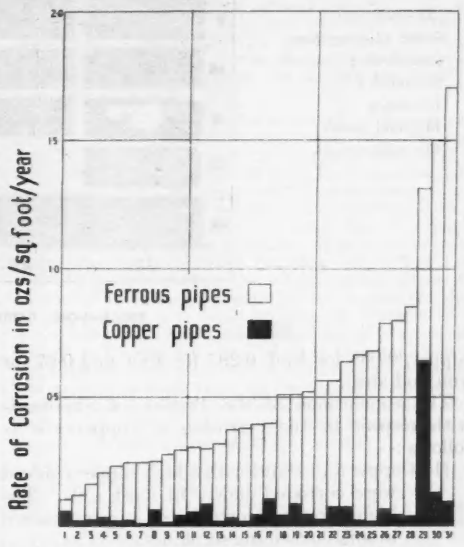


FIG. 4—RELATIVE CORROSION OF FERROUS AND COPPER PIPES IN SOIL

TABLE II.—*Results of Accelerated Corrosion Tests*

Source of soil.	Metal.	Average loss in weight, gms./sq. cm.	Relative loss in weight with respect to steel, per cent.	Maximum depth of pitting (cms.)	Relative depth of pitting with respect to steel, per cent.
Whittier Boulevard	Steel	0·0161	100	0·01017	100
	Copper	0·0012	8	0·00014	1
Saticoy	Steel	0·0548	100	0·07490	100
	Copper	0·0018	3	0·00029	0·4

TABLE IV.

Material.	Very fine sandy loam.		Muck.		Clay.		Tidal marsh.		Alkali soil.	
	Loss *	Pits †	Loss	Pits	Loss	Pits	Loss	Pits	Loss	Pits
Refined lead	0·010	1·1	0·28	1·4	0·068	P	0·062	0·9	0·020	1·1
Chemical lead	0·037	1·7	0·51	1·3	0·18	2·5	0·076	1·2	0·088	1·8
Copper	0·015	M	0·12	S	0·044	P	—	—	0·015	P
Brass	0·077	M, D	0·15	P	0·051	M, D	0·010	M, *d*	0·010	M, D
Bronze	0·015	1·1	0·13	5·5	0·046	M	0·46	1·1	0·049	3·1
Sheet zinc	0·35	4·0	0·46	3·9	0·085	1·7	0·23	3·3	*f*	*f*
Cast zinc	0·34	7·0	0·53	5·5	0·078	1·8	0·22	6·8	0·94	9·8
Sheet zinc	0·19	5·2	0·38	*f*	0·11	2·0	0·45	3·7	*f*	*f*
Aluminium	0·009	2·1	*f*	*f*	0·035	*f*	0·016	P	0·047	*f*
Al–Mn–alloy	0·038	*f*	0·096	*f*	0·020	1·4	0·021	1·3	0·031	1·9
Duralumin	—	—	—	—	0·14	*f*	0·014	M	*f*	*f*
Open-hearth iron	0·98	*f*	0·58	6·2	0·56	7·0	*f*	*f*	*f*	*f*
Steel—0·2 per cent. Cu	*f*	*f*	0·69	*f*	0·54	5·9	*f*	*f*	*f*	*f*

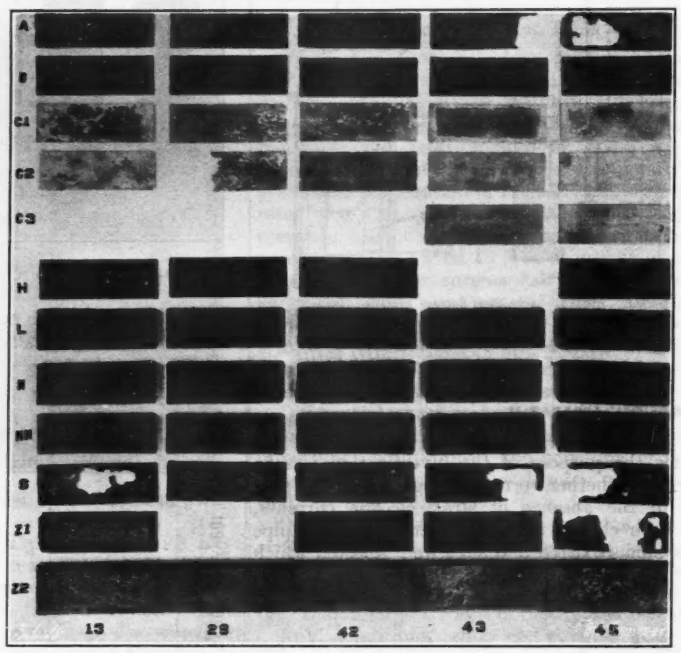
* Loss is given in ounces per square foot per year.
† Rate of maximum penetration in mils per year.
P = Definite pitting, no pits greater than 6 mils.
S = Severe surface corrosion, impossible to measure penetration because of even destruction of surface.
M = Shallow metal attack, roughening of surface but no definite pitting.
D = Dezincification over large areas.
d = Dezincification in spots.
f = Failure of one or more holes.

much more resistant to corrosion than copper.*

Similar results are obtained on comparing the depth of penetration in the deepest pit, and some figures are given in Table III. In a number of other cases there was only roughening of the copper surface and no definite pitting.

As a general rule, the corrosion of copper alloys was greater than that of plain copper, though, since the alloys are generally used for valves, cocks, clamps, &c., where the thickness of metal is appreciably greater than that of the pipe, quite a large difference in corrosion rate is permissible before, in any pipe system, the alloys would be the cause of a breakdown.

The rates of loss of weight and penetration of various metals and alloys exposed in five different soils for a period of ten years is given in Table IV. The actual specimens to which this table refers are illustrated in Fig. 5. The data show the good results obtained with copper in resisting soil corrosion. The average corrosion rate for the results shown is 0·048 oz. per square foot per year for copper, 0·088 for lead, 0·297 for zinc, and 0·67 for iron and steel.



A—open-hearth iron
B—brass
C1—aluminium
C2—Al-Mn alloy
C3—duralumin
H—copper
L—bronze
N—chemical lead
NN—refined lead
S—copper-bearing steel
Z1—rolled zinc
Z2—cast zinc
Soils: 13—very fine sandy loam; 29—muck; 42—clay; 43—tidal marsh; 45—sulphate soil.

FIG. 5—SOIL CORRODED SPECIMENS

The conclusions of the Bureau of Standards with respect to the corrosion of copper are as follows:—

(1) Copper and alloys with a high copper content were corroded slowly in most soils. The highest rates of corrosion of copper occurred in soils containing sulphides.
(2) The rates of corrosion of all copper alloys were higher in cinders than in any type of soil tested.
(3) The corrosion of copper and high-copper alloys was more nearly uniform over the surface than was the corrosion of ferrous materials in most soils.
(4) Muntz metal dezincified in a considerable number of soils and probably should not be exposed to severe soil conditions despite the fact that in one case—a salt marsh—this material was particularly satisfactory.
(5) The rates of corrosion of copper and brass appeared to change less with time than did the corresponding rates for ferrous materials.

(To be continued)

* In practically all the other soils Muntz metal was inferior to copper.

Government Control of Railways

A WHITE Paper, issued on February 8th, gives the following outline of financial arrangements which have been made between the Minister of Transport, the four Amalgamated Railway Companies and the London Passenger Transport Board.

As from September 1st, 1939, the date upon which the Government assumed control, the revenue receipts and expenses of the controlled undertakings will be pooled and the resultant net revenue for each accounting period will be appropriated in accordance with the arrangements set out below.

There will be paid out of the pool to each of the controlled undertakings a minimum sum which, in the case of

(*a*) each of the Railway Companies will be the average of its net revenue for the years 1935, 1936, and 1937;

(*b*) the Board will be the net revenue for the year ended June 30th, 1939;

adjusted as may be necessary for interest on capital issued or redeemed subsequent to the basic period.

These payments (amounting to £40 millions*) will be guaranteed by H.M. Government and are referred to as the guaranteed net revenues. They will accrue to the controlled undertakings approximately in the following proportions:—

	Per cent.
London, Midland and Scottish Railway Company ...	34
London and North Eastern Railway Company	23
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After the payment of the guaranteed net revenues any balance in the pool, up to an amount of £3½ millions,* will be paid to the controlled undertakings in proportion to their respective guaranteed net revenues.

If the net revenue in the pool exceeds the sum of the amounts payable to the controlled undertakings under paragraphs 2 and 3 (£43½ millions *) then, until the sum paid to them reaches £56 millions*, being the estimated sum required to bring the net revenues of the controlled undertakings up to their standard revenues, one half of the excess over £43½ millions will be paid to the Exchequer and the other half will be paid to the controlled undertakings in proportion to their respective guaranteed net revenues: Provided that if the share of any of the controlled undertakings, together with its net revenue from other sources, would result in that undertaking exceeding its standard revenue, the excess will be paid to the other controlled undertakings in proportion to their respective guaranteed net revenues, but so that in any case the total net revenue accruing to a controlled undertaking shall not exceed its standard revenue.

Standard revenue means in relation to a Railway Company the standard revenue ascertained under the Railways Act, 1921, with allowances for additional capital as provided by that Act and in relation to the Board means the net revenue necessary to enable the Board to pay the standard rate of interest on its "C" Stock.

Any net revenue in the pool remaining after the controlled undertakings have received their standard revenues on the basis laid down in the preceding paragraph will be paid to the Exchequer.

In ascertaining the net revenue of a Railway Company there shall be excluded any net revenue derived from investments in road transport undertakings and from ownership of and investments in railways in Northern Ireland or Eire. Net revenue in relation to the Board means the whole of the net revenue of the Board ascertained in accordance with the statutory form of railway accounts.

[NOTE.—Pursuant to the provisions of section 40 of the Civil Defence Act, 1939, repayments will fall to be made by the Railway Companies to the Exchequer of one-half of the grants made for air-raid precautionary measures if net revenues accrue to them in excess of their respective guaranteed net revenues, and by the Board if net revenue accrue to it in excess of its average net revenue for the years ended June 30th, 1937, 1938, and 1939 inclusive.]

After December 31st, 1939, the London Passenger Pooling Scheme will be suspended and any guarantees dependent upon the pool established by that scheme will, during the period of suspension, be related to the pool to be established under these financial arrangements.

For the period of control ended December 31st, 1939, the Exechequer will contribute a sum equal to the amount by which the guaranteed net revenue of the Board for that period exceeds the net revenue which accrued to the Board after the operation of the London Passenger Pooling Scheme during that period. This contribution will form part of the net revenue of the pool.

As between the Board and the Exchequer there will also be payments so as to adjust the net revenue of the Board for the six months ended December 31st, 1939, to the amount of £2,430,000 being the estimated net revenue for the corresponding period of the previous year.

Provision will be made (among other matters) for:

(*a*) the standardisation of charges for maintenance (including renewals) on the basis of the average of the charges made in the basic period, subject to adjustment for altered conditions;

(*b*) the cost of restoring war damage up to a maximum of £10 millions in any full year (and pro rata for part of a year) to be charged to revenue expenditure when the damage occurs;

(*c*) the revenue receipts and expenditure in respect of the requisitioning by the Minister of Transport of privately-owned wagons to be included in the revenue receipts and expenditure of the controlled undertakings.

Rates, fares, and charges will be adjusted to meet variations in working costs and certain other conditions arising from the war and machinery will be provided to this end.

The Minister of Transport or the Railway Companies and the Board jointly may, after the end of the year 1940, propose revision of these arrangements for any cause of a major character and, if agreed, the arrangements shall be revised accordingly.

These arrangements have been agreed between the Government, the Railway Companies, and the Board on the understanding that it will be open to certain other controlled Railway Companies to become parties to the arrangements on similar terms.

* These figures are approximate only.

BRITISH STANDARDS INSTITUTION

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

TEST FOR GALVANISED WIRE

(B.S. 443).—A British Standard Specification for the Testing of the Zinc Coating on Galvanised Wires was issued in 1932. The method employed was the copper sulphate dipping test, but it was at that time appreciated by the B.S.I. Committee that the copper sulphate test left much to be desired as a real criterion of the quality of the galvanising. During the last few years considerable research work has been carried out in many countries, and this is reflected in a new edition of this specification which has just been published. The principal feature of this new edition is the introduction of a test for the minimum weights of zinc per unit area on zinc-coated wires. This test has been introduced in substitution for the copper sulphate test on straight wires, but the latter test is retained for testing wires after being wrapped and unwrapped round a mandrel of specified diameter. Any advantages which the copper sulphate test may possess, such as an indication of the uniformity and concentricity of the coat, are therefore not lost in the new specification, but the specification itself is strengthened by the definition of the minimum weight of coat which the wire itself should carry. The method of determining the weight of coat is the same as that recommended by the American Society for Testing Materials, the wire being stripped of the zinc coating by immersion in a solution of antimony chloride and hydrochloric acid. The minimum weight of coat is graded according to the diameter of the wire, and is expressed in ounces per square foot and in grams per metre. In an appendix some useful formulæ are given for calculating the percentage weight of the zinc coating. In the foreword to the specification it is emphasised that the specification is intended to cover galvanised wire of good commercial quality, and that it is recognised that for certain purposes tests of greater severity may be required. In such cases the existence of this specification is not intended to prejudice purchasers in placing more severe specifications before manufacturers for their acceptance, but it is suggested that in such cases the wire should be specified to the British Standard Specification plus the additional or more severe requirements which the purchaser may require.

AIR-BREAK SWITCHES AND CIRCUIT-BREAKERS

(B.S. 861 and 862).—These two Specifications cover Air-break Switches and Circuit-breakers respectively. They combine in two documents material originally published in six specifications, as follows:—B.S. 861 covers revisions of B.S. 109—1934. Air-break Knife Switches and Air-break Isolating Switches; B.S. 124—1934. Totally-enclosed Air-break Switches; B.S. 126—1930. Flameproof Air-break Switches; B.S. 862 covers revisions of B.S. 110—1934. Air-break Circuit-breakers; B.S. 127—1930. Flameproof Air-break Circuit-breakers; B.S. 130—1934. Totally-enclosed Air-break Circuit-breakers. It is felt that this will facilitate the use of the specifications, many of the clauses of which were common to all.

Rail and Road

NEW LONDON UNDERGROUND STATIONS.—In connection with the extension of the Central Line eastwards from Liverpool Street, the London Passenger Transport Board has placed contracts for the construction of two stations at Leytonstone and Hainault.

THE HERBERT JACKSON PRIZE.—The London Midland and Scottish Railway Company announces that the Herbert Jackson Prize for 1939 has been awarded to Mr. H. I. Andrews, of the Engineering Section, Research Department, Derby, for his paper entitled "The Development of a Refrigerating Machine for use on Trains."

ROAD VEHICLE REGISTRATIONS.—The Secretary to the Ministry of Transport has announced that the number of mechanically-propelled road vehicles registered for the first time in Great Britain during the month of December, 1939, was 9595 compared with 35,181 in December, 1938. Of the 26,018 motor cars taxed on horse power, nearly 17,000 were under 10 H.P. and over 6500 between 10 and 15 H.P.

READING-LIGHTS ON L.M.S. ELECTRIC TRAINS.—The London, Midland and Scottish Railway Company announces that it has now completed the equipment of all its London electric services, 329 train-sets in all, with the approved system of interior lighting. Services benefitting from this equipment are those from Euston and Broad Street to Watford, from Broad Street to Richmond, and the branches to Croxley Green and Rickmansworth.

LOCOMOTIVE INSPECTION IN AMERICA.—The annual report of the United States Bureau of Locomotive Inspection shows that during the year ended June 30th, 1939, there were 105,606 steam locomotives inspected, of which 9099 were found defective and 468 ordered out of service. There were 52 locomotive boiler failures which involved the loss of 15 lives, 55 people being injured. In addition to the steam locomotives inspected, there were 2716 of other types examined and of these 260 were found defective and 14 ordered out of service.

HEAVY G.W.R. RAIL.—In the course of a paper before the Permanent War Institution, Mr. E. T. Hutt mentioned the new 100 lb. rail introduced by the Great Western Railway Company. This rail section is obtained by giving a deeper head to the standard 95 lb. rail with which it is interchangeable, but gives considerably longer crown wear. In the past two years about 7300 tons of this rail has been laid, its use being confined to straight track away from tunnels, water troughs or other conditions where corrosion or side wear is likely to take place before the extra head material has been worn away.

GERMAN AUTOBAHNEN.—According to a correspondent of the *Glasgow Herald*, a number of the German motor roads are to be extended across the former Polish territory. He says that one road will link Stettin and Königsberg, and that the one between Berlin and Frankfurt is being extended to Poznan and a continuation to Lodz is being considered. The existing road to Breslau will be extended to the Upper Silesian industrial area (Kattowitz) and to Cracow. Also, an autobahn from north to south is being planned which is to link Danzig, Bromberg, Poznan, and Breslau, and may be continued to Vienna.

PROPOSED NEW CANADIAN HIGHWAY.—At a meeting of the Royal Automobile Club of Canada it was stated that the construction of a new highway connecting Montreal and the New York State border will be started in the near future. It will be about thirty miles long connecting the Honore Mercier bridge at Caughnawaga, Quebec, with Mooers, New York, and will eliminate the roundabout route which at present has to be followed. According to the statement it will be a divided, four-lane highway, and its construction will involve the building of four underpasses, separating it from railway crossings and three protected intersections.

ELECTRIC ROAD VEHICLES.—A demonstration of electrically propelled road vehicles was recently arranged by the Electrical Development Association in conjunction with the Electric Vehicle Association for the benefit of the Minister of Transport. Speaking on behalf of the Association, Sir Felix Pole pointed out that a van of half a ton capacity could run about two miles to one unit of electricity costing on average between ½d. and ¾d., and to compare with this running cost petrol would have to be reduced to 5d. a gallon. At present there were about 100,000 commercial vehicles in this country travelling between 30 and 40 miles a day and if they were replaced by electric vehicles some 70 million gallons of petrol would be saved per annum.

COVENTRY BY-PASS ROAD.—Particulars of the Coventry by-pass road from Allesley on the north-west of the city to Toll Bar End on the south-east, were given at a recent meeting of the Birmingham and District Association of the Institution of Civil Engineers by Mr. E. H. Ford. Being built at a cost of £350,000, the road is six and seven-eighths miles long whereas the old road through the city is six and a half miles long. There are bridges as part of the road over the rivers Sowe and Sherbourne. Each bridge is 110ft. wide between the parapets and has dual carriage ways 24ft. wide, with 8ft. cycle tracks and footpaths. Mr. Ford mentioned that the road, even at 150ft. wide, could not be looked upon as a "motorway." It is, he said, rather a road adapted for traffic purposes according to modern ideas.

A DOUBLE-DECKED AMERICAN BRIDGE.—The first contract has been awarded for the construction of the piers and abutments of a combined railway and road bridge across the Pit River arm of the Shasta reservoir in the United States. It will have two decks, the lower of which will carry two railroad tracks and the upper, which will be over 530ft. above the level of the stream bed, will carry a 44ft. wide road and two footpaths. The cantilever truss forming the central span will be 630ft. long and there will also be two 497ft., three 282ft., and two 141ft. long truss spans. The girder spans will include one of 150ft. and four of 141ft. length. With a total height of 358ft. the tallest pier will have a base 95ft. by 90ft. and two of the other piers will be over 350ft. high. The complete bridge will cost about five million dollars to build.

Miscellanea

INSURANCE OF COMMODITIES.—The Board of Trade has, with the approval of the Treasury, decided that in respect of the period beginning March 3rd, 1940, and ending June 2nd, 1940, the rate of premium payable under any policy of insurance issued under the commodity insurance scheme shall continue to be at the rate of five shillings per cent. per month.

INSPECTOR OF MINES ANNUAL REPORT.—The annual report of H.M. Chief Inspector of Mines shows that during the year ended September 30th, 1938, the coal output of this country for the twelve months totalled 227 million tons, or 18·2 per cent. of the world's production. The average net selling price of all the saleable coal raised was 16s. 7¼d. per ton.

LOW TEMPERATURE CARBONISATION, LTD.—The Secretary for Mines, in a written reply in the House of Commons' recently stated that he had been informed by Low Temperature Carbonisation, Ltd., that for some weeks past the company has been engaged in heating up the retorts at Pencoed, South Wales, to the operating temperature, and that it is intended at first to carbonise charges of coal in 72 retorts. Carbonisation in a further 72 retorts will follow in a short time.

PROPOSED ELECTRICITY GRID IN AMERICA.—Representatives of a number of large public utility companies with power stations in the eastern part of the United States have attended conferences to investigate a proposal for the construction of a network of high voltage lines interconnecting the larger power plants and industrial centres in the area. The lines would interconnect both privately and publicly owned stations irrespective as to whether they were steam or hydro-electric and the cost of such a scheme is estimated at one hundred million pounds.

CAUSE OF NORTH WALES ELECTRICITY SUPPLY INTERRUPTION.—A statement has been made by Mr. R. A. S. Thwaites, the engineer and general manager of the North Wales Power Company, with regard to the interruption of the electricity supply in North Wales during the recent bad weather. He attributed the trouble to fine particles of rain and ice freezing round the overhead conductors, so that in isolated positions on high ground the normal ⅝in. diameter was sometimes increased to more than 4in. The extra weight, together with a wind of high velocity, was in some instances enough to break the conductors, bend the ironwork, smash the insulator pins and even to drag the poles to within 6ft. of the ground. Conway, Colwyn Bay, and Llandudno were normally fed by five different circuits, but all were put out of action.

ROAD ACCIDENTS.—We have just read a little pamphlet written by a veteran motorist—Sir Alfred Herbert—on Road Accidents, and commend it cordially to the attention of drivers, whether they regard themselves as experts or not, and to pedestrians. It is written primarily for motorists but something equally explicit and as clearly written is needed for pedestrians. We have it from the direct evidence of special constables that the carelessness of pedestrians is colossal. Sir Alfred warns motorists against the drinking of alcohol just before driving; if the same advice were given to pedestrians there would be fewer road casualties. At closing time crowds of more or less excited people spread themselves over the road without a thought and certainly without giving their eyes, as the author recommends, two minutes to adjust themselves to the dark. Copies of the pamphlet can be obtained from Sir Alfred Herbert, K.B.E., at Dunley Manor, Whitchurch, Hants.

AIR CONDITIONING PLANT AT A DEEP GOLD MINE.—A paper presented by Messrs. J. Spalding and T. W. Parker before the Institution of Mining and Metallurgy describes the air conditioning plant at the Ooregum mine in the Kolar Gold Field. This mine is one of the deepest in the world, its present bottom level being 8330ft. below surface. At a vertical depth of 8000ft. the initial rock temperature is 134 deg. Fah., the temperature increasing about 9 deg. Fah. for each additional 1000ft. of depth. The paper is in three parts, the first describing the conditions which led to the installation of an air conditioning plant at surface after the economic limits of ventilation by fans had been reached. The second part describes the plant installed which was an ammonia refrigerating plant to cool 10,000lb. of air per minute from an intake wet bulb temperature of 73 deg. Fah. to 40 deg. Fah. (saturated) equivalent to 13,674,000 B.Th.U. per hour. The third part of the paper deals with the ventilation circuit of the mine and the cooling effect obtained underground by the air conditioning plant.

A LARGE NEON CLOCK.—What is claimed to be the largest neon sign in Europe has been erected in the form of a clock on a tall steel tower in the centre of Stockholm in Sweden. This tower is over what was originally the principal telephone exchange and wires from it passed overhead to all parts of the city. It has not been used for some years as all the cables are now carried in underground conduits. On it has been mounted the illuminated revolving clock containing some 105 m. of neon tubes. The rotating part of the equipment displays on one side the letters N. K., and on the other side the dial and hands of the clock. The dial has a diameter of 7 m. and consists of a welded iron ring, stayed by cross members. The stationary mast consists of a 35 mm. seamless tube and inside the mast is the shaft which turns the clock, running from the motor room up to the centre of the dial, where a welded sheet steel box encloses the gears for the hands. Two radial and one thrust ball bearings support the total load and a 1 H.P. geared motor turns the clock at the rate of 4 r.p.m. An electrically driven master clock gives minute impulses to turn the hands one minute at a time. The shaft for this runs inside the main shaft up to the gears for the hands in the centre of the clock. The minute hand is 4½ m. long and weighs 44 kilograms. On the back are 22 mm. light-green neon tubes for the sign, and on the dial side red 22 mm. neon tubes for the face and the hands. The neon tubes and the transformers are connected by a system which enables the light strength to be regulated from the motor room. The whole equipment weighs 7 tons.

Air and Water

THE CONSULTING MARINE ENGINEERS.—At a meeting of the council of the Society of Consulting Marine Engineers and Ship Surveyors, Mr. H. E. J. Camps was nominated to succeed Mr. Sterry B. Freeman as president for the coming year. Mr. H. M. Harte and Mr. George M. Cousins were nominated to continue as vice-presidents for another year.

SKIS FOR WARPLANES.—For the use of modern, fast aircraft, operating in countries where winter brings long periods of snow and ice, the National Research Council of Canada evolved a new and more efficient type of ski. The earlier stream-lined runners, produced in the council's laboratories, are now superseded by skis which have a low sliding resistance and which are better able to withstand "freezing in" and wear.

LOSS OF H.M.S. SPHINX.—Whilst the minesweeper H.M.S. "Sphinx" was being towed into port after being damaged in an air attack on Saturday, February 3rd, she capsized and five officers and 49 ratings lost their lives. She was an 875 tons vessel of the "Halcyon" class and was launched in February last from the yard of William Hamilton and Co., Ltd. Her armament consisted of two 4in. and five smaller guns.

AERODROMES IN BRITAIN.—At the annual dinner of the Aerodrome Owners Association it was stated by Mr. J. G. Gibson that at the end of August last there were 69 licensed and 50 private aerodromes in this country. In the course of his remarks after the dinner, Lord Londonderry said that every big town in the country should have had an aerodrome or at any rate a suitable landing ground for which the Government should have borne half the cost.

SINKING OF THE "BEAVERBURN" AND THE "MUNSTER."—On Monday, February 5th, the Canadian Pacific cargo vessel "Beaverburn" was torpedoed and sunk off the south-west coast of England. She was a ship of 9874 gross tons, built in 1927 by William Denny and Brothers, Ltd., and was one of five ships of the Beaver class employed in the company's service between the St. Lawrence and the Thames. With one exception, the whole of her crew of 77 have been accounted for. On Wednesday, February 7th, the passenger and cargo cross channel motor ship "Munster" of 4305 tons was blown up and sunk when on the Liverpool-Northern Ireland crossing. She was owned by Court Lines, Ltd., and was built in 1938 by Harland and Wolff, Ltd. With her sister ship, the "Leinster," she was the largest cross channel motorship in the world, having accommodation for 425 first class and 110 third class passengers.

SHIPBUILDING AND THE GOVERNMENT.—Replying to a question in the House of Commons recently, the First Lord of the Admiralty said that merchant ships built by the Admiralty will be delivered to the Ministry of Shipping, which will make arrangements for their management. Vessels now building for private owners will not, so far as can at present be foreseen, be transferred to Government ownership, but will be subject to requisition or other control by the Minister of Shipping. The First Lord was also asked whether the scheme under which the Admiralty becomes responsible for all mercantile shipbuilding and repairs would include the transfer of all shipbuilding and repair establishments to Government control and ownership, and whether the employees in such establishments would become Government employees. The answer to both parts of the question was in the negative, there being no intention of preventing shipbuilding on private account, and the Admiralty is responsible for issuing licences for this purpose.

ENGINEERING APPRENTICES AND THE MERCHANT SERVICE.—The attention of the Minister of Shipping has been called to the fact that engineering apprentices whose intention is to join the Mercantile Marine as junior engineer officers are in some doubt as to the action they should take when called upon to register under the National Service (Armed Forces) Act, 1939. This matter has been discussed, and it has been arranged that all engineering apprentices who intend to become engineer officers in the Mercantile Marine should be registered as "seafaring." All such apprentices should inform the Ministry of Labour clerk of this intention at the time of registration in order that their registration papers may be marked accordingly and transferred to the appropriate Mercantile Marine Office. As soon as possible after registration apprentices will be asked by the Registrar General of Shipping and Seamen for information as to the extent to which their apprenticeship has been completed, &c., but until instructed otherwise they should continue in their present employment.

AIRCRAFT AT THE SCIENCE MUSEUM.—The Main Hall of the Science Museum, South Kensington, was reopened on Wednesday, February 14th, with a special exhibition illustrative of "Aircraft in Peace and War." Two other galleries containing transport collections, and one specially intended for children, were also opened. The exhibition, "Aircraft in Peace and War," has been formed with exhibits from the permanent National Aeronautical Collection supplemented by others contributed by the Air Ministry, the Ministry of Information, the aeronautical press, and the aircraft industry. Its purpose is to show how the flying machine has been developed and used from the time of its invention up to the present day, while it also illustrates the importance of flight as a means of communication and a weapon of war. The exhibits are arranged in four groups which represent distinctive periods, viz.: The Historic Period (1903–14), the Great War (1914–18), Civil and Military Aviation (1919–39), and Aeroplanes of the Royal Air Force (1940). The display begins with a model of the first successful aeroplane—and, tracing the technical progress and its application through the vicissitudes of peace and war, ends with the aeroplanes used by the Royal Air Force at present. This development is shown by 120 scale models of aircraft arranged in chronological order and supplemented by examples of aero engines used in civil aircraft and Royal Air Force machines to-day. Photographs illustrate various aspects of civil air transport and the use of the aeroplane in war.

THE DRAINING OF THE ISERE VALLEY AT GRENOBLE

(For description see page 150)

FIG. 11—GENERAL VIEW OF WORK IN PROGRESS

FIG. 13—TELESCOPIC FORMS FOR CONCRETE ARCH

FIG. 12—SINKING A WELL AND BUILDING EARTH DAM ON ETANG DU GENIE

FIG. 14—JUNCTION OF MAIN CONDUIT AND VERDERET CULVERT

Pencil Portrait No. 23

A. AUGUSTIN-NORMAND

UNIV. OF MICH.

DRAWN FOR THE ENGINEER BY ELLIOTT & FRY

The Engineer

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NOTICES TO READERS

EMERGENCY MEASURES

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Copies of THE ENGINEER can be obtained at 28, Essex Street from Friday mornings.

PAPER SUPPLIES

With a view to the conservation of paper readers are advised, in the interests of all concerned, to place a regular order for "The Engineer" with their newsagent or direct with the Publisher.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGE OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address : "The Engineer," 28, Essex Street, Strand, London, W.C.2.

Telegraphic Address : "Engineer Newspaper, Estrand, London." Telephone : CENtral 6565 (10 lines).

Pencil Portrait No. 23

With this issue we present a Pencil Portrait of Monsieur A. Augustin-Normand, M.I.N.A., the well-known French shipbuilder of Le Havre.

THE BASIC EFFICIENCY OF POWER STATIONS

THE competition amongst power station engineers to attain an honourable place for their plants in the list of thermal efficiencies recorded annually by the Electricity Commissioners has caused them to pay increasing attention to the heat cycles on which their stations operate. It is obviously unreasonable to expect a plant working with steam at, say, 300 lb. pressure, 700 deg. Fah. and a vacuum of 28in., to compete on equal terms with one using steam at 800 lb. 850 deg. Fah. and a vacuum of 29in. or over, especially if the second case includes a modern system of regenerative feed-heating. For every set of steam and feed water conditions there is some particular maximum efficiency which would be attainable by a plant with ideally perfect boilers and machinery, and it is this so-called "basic efficiency" of the station which is the only criterion with which its actual performances can fairly be compared. To make such comparisons possible it has, of course, to be assumed that every unit in the station works on the same heat cycle. Furthermore, for scientific exactitude, the lower temperature of the cycle should really be that of the circulating water at inlet, and not that of the vacuum, although this refinement is generally ignored.

Before the performance of a station can be compared with its particular basic efficiency, it is necessary to decide upon the manner in which the basic efficiency is to be computed. In the days before regenerative feed-heating this was a simple matter, for the basic efficiency was then merely the ratio of the available heat in a pound of steam at the initial temperature and pressure, to the total heat put into it by the boiler. The practice of heating the feed-water progressively by steam extracted from the turbine at various points introduced complications. Some engineers think it right to make the calculation as if the feedwater in the ideal cycle were heated by the same number of distinct steps as were adopted in the actual plant. This makes a tedious computation, but justification has been claimed for it on the grounds that the performance of any particular plant can only properly be compared with that of an ideal plant having the same elements. The argument is a plausible one but it leads to difficulties. In an ideal plant it would not be possible for the feed-water to be heated in a series of stages by extracted steam, for this would necessitate the steam at each stage giving up heat to water entering that stage at a lower temperature. Such a process would be irreversible, and could not therefore take place in a thermodynamically perfect apparatus such as the ideal plant is supposed to be. Moreover, if the process were admitted for the reason that it conformed with practice, the same argument might be used for justifying the assumption of non-adiabatic expansion of steam in the turbine, and the whole conception of an ideal plant would go by the board. Logic and simplicity are both on the side of those who maintain that every ideal cycle must be thermodynamically reversible, and consequently that whenever regenerative heating of the feedwater is included in the cycle, this must be assumed to take place by a continuous contra-flow process to which stage-heating endeavours to approximate. On this assumption, when computing the cycle efficiency, we have only to take into account the final temperature reached by the feed-water, and the calculation is enormously simplified.

The divergence of opinion as to how the ideal efficiency of a regenerative cycle should be computed has existed ever since regenerative feed-heating came into practice, and no acceptable ruling on the subject has ever been forthcoming from any authoritative body. The Heat Engine Trials Committee advocated one principle in its provisional report of 1926, but changed its opinion before its final report in 1927, and eventually proposed a scheme that seems to meet with no favour from anybody, for it is neither one thing nor the other. The question has again been brought into the foreground by the comparison of ideal cycles in the recent Thomas Hawksley Lecture of Sir Leonard Pearce. In the Appendix to that Lecture the author accepts the principle of feed-heating by finite stages, but eliminates the large amount of calculation it entails by providing charts which enable a result to be arrived at almost immediately. The assumptions on which these charts have been prepared are carefully explained so that the user should be under no misapprehension as to what he is doing. One of these assumptions is that at each stage the feed-water is raised to the full temperature of the steam entering the heater. Such a condition is, of course, unattainable in practice, and its postulation must be regarded as an attempt to approach that thermodynamic perfection which is rendered impossible by the assumption of finite stages. Another hypothesis underlying the charts is that the temperature of the feed-water is raised by steps of about 50 deg. Fah. at a time. This may be quite reasonable, but reference to the nearest data at hand shows that in the first case of which particulars are available, a final feed temperature of 290 deg. Fah. is attained by the following successive steps: 3 deg. Fah. in the air-ejector, 13·5 deg. Fah. in the drain cooler, and 72deg. Fah., 41 deg. Fah., and 82 deg. Fah. respectively in the three regular heaters.

Since conditions like this are to be met with in current practice, it is surely better to determine the cycle efficiency in all cases by a method which is not only thermodynamically irreproachable when applied to any of them, but has the further advantage of extreme simplicity. The whole calculation, indeed, consists of nothing more than the application of ordinary arithmetic to five numbers that can be taken directly from the steam tables. A glance at a temperature-entropy diagram will make the procedure self-evident. All that has to be done is first to find the numerical difference between the total heat in a pound of the live steam, and the total heat in a pound of the hot feed-water. From this difference has to be subtracted the heat rejected to the condenser, and the remainder, divided by the difference first obtained, gives the basic efficiency of the cycle. This method, which was advocated, and probably originated, by the late Capt. Sankey, is thoroughly practical as it requires only a few minutes work and access to a set of steam tables. Its general acceptance would put an end to a lot of controversy.

The Wrong Way and the Right

WAS it the "Professor" who remarked at the "Breakfast Table" that the world could be divided into two sorts of people—those who did things, and those who wanted to know why they had not been done differently? Save for the fact that few people care a twopenny piece one way or the other the assertion crystallises a common experience. And fortunate it is that it is so. If everyone accepted the way that things were done as the only way of doing them we should get on mighty slowly. Providentially—if the progress of the world may be regarded as advancement—there are always a hundred critics to one doer; tiresome "Nosey Parkers" if you like, who are never satisfied but must always be wanting to know why things are done as they are done, and if they could not be better done in another way. Of such stuff are researchers and inventors made. At some time in the motto age of good Queen Victoria some dimity lady in her little school for the children of gentlefolk made careless pupils write out in pothooks and hangers, "There is a right way and a wrong way of doing everything." The copy book and the sampler gave perpetuity to an assertion which must have been manifestly false even whilst it was still wet on the paper or still glowing in wool or silk on the canvas. There is never, or hardly ever, one right way and one wrong way of doing anything. The number of wrong ways is legion, and the right ways are many. Only when we are on the knife edge of perfection can we say that there is but one way and one way only. So long as the world continues to be blessed by its departure from perfection there will always be more ways of killing a cat than hanging it; more ways than one of scaling the mountains, more ways than one of accomplishing anything that we have it in our hearts to attempt.

Engineering is loaded down with examples.

One might think that in the simple matter of locking a nut there must be a one and only best way. If that is so, no one has found it. The patent offices of the world are cluttered up with lock-nuts and never a year passes but a few new ones are added to the pile. Again it might be thought, not unreasonably, that the intelligence of engineers would have found by now the right way of attaching the blades in a turbine disc. Yet a dozen makers have a dozen different ways of doing it, and since all are effective it cannot be said that one is more right than another. Or consider the numbers of types of steam boilers all giving about the same efficiency. Is there any right way and wrong way there? Once more; it might be thought that in machining operations at least one way would be unquestionably better than any other. Makers of machines will claim that it is, but as they all make the claim for their own method we are left just where we were; that is, in the knowledge that in engineering there are often as many right ways of doing things as wrong ways. And it is even chances that where the right way has become established it is no more than a convention, and the sooner it is knocked on the head the better. Few of us know what slaves we are to that master and how often the "easy chair of custom" induces us to believe that we know the right way. Perhaps the success of the ingenious people who go about the world making a comfortable living out of telling other people how they ought to do their job is due to nothing more than that they are able to see where convention is tightening its tentacles. They break it down and replace it by another which, years hence, some later ingenious gentleman in his turn will receive a handsome fee for rupturing. Philosophers tell us that the only facts man can be positive about in this world are those he has made himself—"facts" like Euclid's definitions for example. All our other scientific facts or laws are no more than the assertion of the repetition of phenomena. We accept Boyle's Law because the relationship between pressure and volume always repeats itself. But as far as our knowledge goes, there is nothing fundamental about it; no irrefragable reason why the volume should vary inversely as the pressure. It is much the same with rights and wrongs. Those that we have made for ourselves are positively right; those that are not subject to human definition may be right or wrong. The right-handedness of screw threads may be cited. The odd thing is that if women had invented the corkscrew it would have been left-handed! Man finds it easier to turn his hand outwards from pronation to supination; woman finds it easier to reverse the process. The anatomist will tell you it probably has something to do with holding babies to the breast. Even so it is certain that the normal screw thread would have been left-handed if it were not for the fact that engineers ages and ages ago started putting the driving headstocks of their lathes on the left hand. To us that seems now quite natural. But is it? Would it not have been more natural to have the important part of the lathe under the command of the right hand? A thousand things in mechanical engineering have grown up round that position of the headstock, and it has become right because if we began "monkeying about" with it all those thousand things would be upset. In other words we are tied by our own self-made convention as rigidly as Euclid was by his definitions.

It is not always true that the conventional way which we think is the right way is any better than an unconventional way. But we do not like the unconventional way; we like to be able to say positively and finally that it is the wrong way. Once our ideas have become ingrained we hate to have them upset. When a Joyce writes or a Van Gogh paints in a manner we are not accustomed to, we rebel. We say it is not the right way of writing or painting and our indignation flares up. We may be quite sure that Silas Wegg hated Mr. Boffin far, far more because he had robbed him of "Uncle Parker" than because he inherited riches. Silas would never have called him the "minion of fortune and slave of the hour," would never have conspired with Mr. Venus to hold his nose to the grindstone till the sparks flew out in showers had not he, Silas, built up for himself and established in his mind the belief that the "corner house not far from Cavendish Square" was inhabited by Miss Elizabeth, Master George, Aunt Jane, and Uncle Parker. To Silas Wegg that family was right; Mr. and Mrs. Boffin were wrong. And the moral of that is that there is a good deal of Silas Wegg in all of us.

Electrical Research

THE nineteenth annual report of the British Electrical and Allied Industries Research Association covering the year October 1st, 1938, to September 30th, 1939, contains, as in previous reports, a large amount of information concerning the work the association has undertaken. Lord Stamp, who became president last year, has consented to remain in office for another year, but the usual presidential address and luncheon to which collaborators and others interested in the work of the association have been invited in previous years have been abandoned. Recognising the value of research in war time, the Government has decided that all important members of the association's staff are in a reserved occupation. Moreover, a letter has been received from the Department of Scientific and Industrial Research, stating that the advisory council of the Department not only deprecates any reduction in the activities of the association, but that it should be "infused" with even greater vigour than before.

The programmes of work in hand have been reviewed from the standpoint of priority and steps taken to enable less urgent work to be delayed to admit of prompt attention being given to new and more urgent proposals. Experience since war was declared shows that the association has the full support of the whole industry and some progress has been made in extending its membership. Continued and increasing support is being received by the association from its overseas members in the Commonwealth of Australia, New Zealand, India, and South Africa, where the association's technical reports are assisting in the solution of many problems.

Arising out of negotiations with the Department of Scientific and Industrial Research for financial support for a further five years, representatives of the advisory council made an inspection of the association's laboratory. The report of the inspectors was entirely favourable to the association, but the fact was recognised that the unforeseen rapid increase in the work undertaken at the laboratory had resulted in considerable overcrowding and it was evident that further extension of the building and equipment was required as indeed was foreshadowed in the previous annual report. Accordingly, after consideration of possible future requirements with a view to utilising the site to the best advantage and after a study of recent developments in the construction of similar buildings, plans were prepared for a new three-storey building across the site behind the present laboratory, leaving a large area of land as yet undisturbed at the back. An extension adding about 4000 square feet of useful laboratory floor space was estimated to cost £7500 and provision was made for that sum. Notwithstanding increased prices, it is believed that the original estimate will prove adequate for the completion of the extension. The small chemical department in the laboratory is becoming increasingly useful, and the good work to which it is devoted is referred to in several sections of the report.

Through their representatives on its council and on its research committees, the association maintains close liaison with its supporting bodies, and is in this way able to ensure that the new researches planned are adequate to meet the growing and varying needs of the industry. Close contact is also maintained in matters of common interest with the British Standards Institution, the National Physical Laboratory, and with other engineering, technical, scientific, and educational institutions not included amongst the association's supporters. Liaison is also maintained with the fighting services and other Government departments, mainly through their representatives on committees dealing with matters of common interest, but it is felt, especially in war time, that greater use might be made of the association when the services it can render in the national interest are better understood.

During the year reports representing important technical progress or containing information urgently required by the industry were presented and accepted for publication by the Institution of Electrical Engineers, and have thus reached a much larger number of persons than are directly covered by the association's membership. At the assembly of the Conference International des Grand Réseaux Electriques held in Paris in the summer, the association presented several important papers on behalf of the industry and also undertook responsibility for secretarial work as part of its contribution in support of the British National Committee of the Conference.

Researches carried out by the association during the year are too numerous to be mentioned individually. One of the new developments is the study of problems arising from the heating of buildings by electricity with special reference to schools; it has been found that there is scope for work on the economical and technical sides. It has been thought desirable to co-ordinate research on features in building construction and ventilation, on the choice of different methods of heating, and on the incidence on economics of supply, including tariffs, and to secure that designers, architects, salesmen, and others are adequately informed on these several aspects and their inter-relation. Recommendations made by a conference called by the association at which all interests were represented are now being pursued by the council.

Preliminary enquiries have shown the need for instrumental aid in dealing to the best advantage with many important problems relating to distribution systems and enquiry is being made concerning available network analysers and possible useful developments in this field.

The comprehensive study and trials of fire fighting appliances and requirements in relation to electrical plant and fire risks have been actively pursued to a conclusion and a timely report issued. Some work remains to be done and it is particularly desired that in this, as in other fields in which urgent matters are occupying the minds of many persons, those most concerned and having ideas worth pursuing will make their comments promptly so that their needs may be catered for without delay.

Encouraged by the Electricity Commissioners and others there has been expansion and acceleration of the work relating to rural electrification and there is considered to be little doubt that one result of the pooling of ideas will be a simplification of practice and reduced cost of distribution. On the agricultural and horticultural sides, programmes have been arranged in co-operation with the agricultural and horticultural interests to secure the more effective utilisation of electricity in many directions.

As an important part of the work on surge phenomena carried out for the Central Electricity Board, the staff has sought to develop new and better apparatus and methods of dealing with disturbances, particularly with lightning. As a result of the intensive work done, certain possibilities emerged and were pursued successfully, resulting in the development of a new type of surge filter performing the functions of present lightning arresters and surge absorbers in a manner showing material advantages and admitting of production at low cost. At the end of the year a semi-commercial model was under construction.

The reports on radio interference issued by the association form probably the most comprehensive survey of the subject that has been made. No fewer than twenty-one reports were available at the end of the period under review and of these six were issued during the year. These reports are published by the association at a normal price and are distributed free to interested bodies, such as the British Standards Institution and the Institution of Electrical Engineers, by whom they are used in preparing standards and regulations.

The fundamental work being done on the subject of dielectrics is increasing in interest, but is as yet mainly of a type appealing to the expert. The same is true of work being carried out on magnetic materials, and in both instances the experts on the industrial side are maintaining close contact and conducting parallel investigations with a view to

utilising all additions to knowledge coming from the laboratories. Work on impulse phenomena at the E.R.A. laboratory is attracting considerable interest; likewise the investigations planned to secure warning of incipient breakdown before disaster occurs.

As foreshadowed in the previous annual report a complete annotated list of reports has now been issued. This is a classified list, complete to October 1938, and should enable members readily to trace a report on a given subject. As it is not proposed to revise it for several years it is in book form. Meanwhile it is kept up to date by the issue of supplements bi-monthly, collated annually, and by an annual list of published reports. For the convenience of members familiar with the work of particular sections, there is also issued an annual sectional list of reports, being a numerical list arranged in accordance with the sectional divisions of the researches. Substantial additions were made during the year to the association's joint library at the head office, and the laboratory. The association's comprehensive card index system which is classified by the universal decimal system now includes upwards of 20,000 subject references. As foreshadowed in the last annual report, the association applied during the year for a new agreement through the Department of Scientific and Industrial Research for continuation of financial support by H.M. Government for a further period of five years. This has been secured, but it could hardly be expected that the association, now well established, should receive assistance on the same scale as in the previous quinquennium, and under the new agreement the E.R.A. has to find a larger sum, viz. £48,000, to qualify for a block grant of £12,000 and the sliding scale grant is reduced to 13s. 4d. in the pound. After hearing the association's representatives, however, the Department agreed to the maximum grant of £26,000 without reduction. In the year now closed, the association has again earned the maximum grant on the old scale, but in the year to come this will not be possible. Unless the support given by members continues to grow during the next few years the council may find it necessary to check the flow of fresh commitments or again to deplete the resources to an undesirably low level.

Obituary

JOHN HOLLOWAY

Many of our readers, expecially those in the Midlands and on the Clyde, where John Holloway spent many years, will learn with regret of his death, which took place at his home at Burnham Bucks, on Sunday, February 11th. He was trained in high-speed engine and turbine work, and served on the management staffs of Bellis and Morcom, Ltd., of Birmingham, and J. Samuel White and Co., Ltd., of Cowes. Later in his career he jointed the staff of James Howden and Co., Ltd., of Glasgow, as works manager, and was responsible for the layout and organisation of the turbine works at Govan. When the manufacture of marine oil engines was taken up by the North British Diesel Engine Works, Ltd., at Whiteinch, he assisted Mr. Randolph Smith in the design and layout of the works and became works general manager, a position he occupied for several years. He then left the Clyde and came to London to establish a practice as works and factory consultant in Victoria Street. New works which he was associated with in the design and layout included those of Hunter Penrose, Ltd., of London and Wellingborough, Colgate-Palmolive-Peet, Ltd., and Broom and Wade, Ltd., of High Wycombe. In recent years he found time to write on his favourite subject of machine tools, and during the early part of 1936 he contributed to THE ENGINEER a series of articles on "British Machine Tool Makers." In 1939 he contributed a series entitled "Industries in and Around London." He was also an inventor and designed a pressure balance air compressor and a non-reactive pneumatic hammer.

ARTHUR STOWEY BAILEY

It is with deep regret that we record the death on Sunday, February 11th, at his home at Moor Park, Herts. of Mr. A. S. Bailey, a railway engineer who saw many years of service in India, and who during the last war was the general manager of the National Ordnance Factory, which was built by Cammell Laird and Co., Ltd., at Nottingham. When the rolling stock building departments of Cammel Laird's and Vickers were amalgamated, Mr. Bailey became the managing director of the Metropolitan-Cammel Carriage and Wagon Company, Ltd., a position which he held with distinction until his retirement in 1933. He was educated privately and in his training specialised in railway work. He held positions with the Metropolitan District Railway and the London and South Western Railway. For some time he was on the staff of Sir Alexander Rendel and Son. His first Indian appointment was with the East Indian Railway at Jamalpur, where he was works manager, and was subsequently appointed deputy locomotive superintendent. He made his reputation however when he was appointed the chief mechanical engineer of the Bengal-Nagpur Railway, and was entrusted with the design and laying out of the company's new works at the railway town of Khargpur. On leaving India in 1911, he joined Cammell Laird and Co., Ltd., and before being appointed to the Nottingham works he was at the London office of the firm and made many journeys abroad in connection with the development of the firm's business in railway accessories. His death at the age of 72 will be a loss to many friends and colleagues, for he will be remembered not only as a good railway engineer, but as a man who was a born leader, and one who was looked up to by all who were privileged to work with and under his guidance.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LIGHT WEIGHT STEAM PLANT

SIR,—When a certain water supply undertaking called for tenders for the supply of portable steam turbines, they stipulated that the weight should not exceed a certain figure.

These plants have now been supplied, and the writer has seen at least one of them described in the technical press.

From the point of view of one who wishes to see steam power survive, it is unfortunate that the weight limit was fixed at such a high figure. To state that a 350 H.P. turbine with gears, condenser, and auxiliaries, weighs less than seven tons hardly gives the impression of lightness; if it is presumed that the weight is between six and seven tons, and we take the mean, the weight per B.H.P. is 41·7 lb.

Now let us consider the power weight ratio of one of the lightest steam plants in general use. Our J class destroyers have a displacement of 1690 tons, and are capable of 40,000 H.P. This gives a weight of 94 lb. per H.P., for ship, machinery, and fighting equipment. Much could be done to reduce the weight of destroyer machinery, but even with that of conventional design, the power weight ratio is vastly better than that of the "portable" set.

The real trouble is that the so called heavy industries live up to their name, and take no notice of, or interest in, the technique made available to all by the researches of the motor and aircraft industries. A draughtsman, in the ordinary engineering industry, makes an inspection cover of a non pressure vessel from a slab of cast iron ¾in. thick, held on by perhaps four ¾in. studs. In the motor industry the same purpose is served by a neat pressing of 18 gauge steel held on by a number of ¼in. studs.

If it is possible to make a reliable aero engine for slightly over one pound per H.P., and Diesel engines for continuous running are available for less than ten pounds per H.P., it hardly seems reasonable to regard 40 lb. per H.P. as a light plant, particularly as the boiler is not included in this weight.

By using the same methods of construction as are used by the lighter industries, it would be easy to build a condensing turbine and gear for 1 lb. per H.P. The actual cooling surface of the condenser (270 square feet) need not weigh more than 700 lb., *i.e.* two pounds per H.P. It should be possible to make the condenser shell for no greater weight than that of its surface, thus we have turbine and condenser for 5 lb. per H.P., add to this 350 lb. for condenser auxiliaries. A *practical* plant for 6 lb. per H.P. is a possibility; yet contraptions weighing as much as 40 lb. per H.P. are made.

A large number of back pressure turbines are in use for various duties; and for some of these duties lightness would be a real advantage, 1 lb. per H.P. is quite practical.

As long as the outlook of builders and users of such plant is bounded by heavy iron and steel castings, antiquated standards, and lack of inspiration, there seems little hope of steam plant developing to the extent that is possible in the direction of lightness.

R. C. MCLEOD, A.C.G.I., A.M.Inst. Mech. E.

Sixty Years Ago

DODGSON ON EUCLID

WE have never been able to develop much sympathy with those who complain that Euclid's "Elements" has a stultifying influence on the minds of the young and that it should be abolished from the class rooms in favour of some less formal, more humanly practical means of teaching geometry. Many "revised versions" of Euclid have been published, but we have never seen one which, in our view, was a whit more logical or in any way easier to understand than the ancient Greek classic. The sad truth would appear to be that the vast majority of the inhabitants of this world are condemned from birth to be excluded from Euclid's portals and that no attempt to smooth the approach to them will ever gain their admittance. The minority are endowed from the start with that which will secure them the right of entry and they will attain it despite all obstacles in their path. If we are accused of prejudice in this matter, as we probably shall be, we would summon to our support Charles L. Dodgson, who in a book, "Euclid and his Modern Rivals," reviewed in our issue of February 13th, 1880, came down heavily on the side of the old geometer and defended him strenuously against the well-meaning but ill-advised attempts of those who would have amended his "verbose, stiff, formal, antiquated, and infelicitous" methods and style. In our review we disclaimed any intention of attempting to judge between the old and the new schools of geometrical thought. Nevertheless in one passage we seem to have forgotten our intended impartiality and to have leant more than a little towards the modernistic side. Mr. Dodgson, we said, looked at the question more from the point of view of a schoolmaster than from that of a man of the world. The schoolmaster's function was to turn out a machine as perfect as may be in the shortest possible time. Man had to work, not to dream, in the world and his school days were spent to gain the necessary equipment. If there was any system of geometry that would give the same knowledge in less time than other systems it was the one which should be adopted. . . . It would be beside the point to-day to criticise these remarks, to emphasise the picture which they suggest of the schoolmaster as a means of manufacturing "machines" for solving mathematical problems. The abiding interest in the review has nothing to do with geometry, old or new, but in the words "Man has to work, not to dream, in the world." When we allowed that remark to slip from the point of our pen we must have known that "Mr. Dodgson neither claimed nor acknowledged any connection with books not published under his name." Equally, however, we must have known the open secret that he had written fifteen years previously, under another name, a book, the instant and surviving fame of which was, and is, founded entirely on its remoteness from work and its mergence in dreaming. Even a geometer—whether of the old or the new school—need suffer no loss of self-respect if he makes the admission that as a force promoting the welfare and happiness of the world the books of Euclid have a serious rival in the books of "Lewis Carroll."

BOOKS RECEIVED

Drawing and Tracing. By H. P. Smith, B.Sc. London: Crosby Lockwood and Son, Ltd., Stationers Hall Court, E.C.4. Price 2s. 6d. net.

Standard Screw Threads and Twist Drills. By G. Gentry. London: Percival Marshall and Co., Ltd., 60, Kingsway, W.C.2. Price 1s. 6d. net.

Collected Researches on Cylinder Wear. By C. G. Williams. Brentford: Institution of Automobile Engineers, Great West Road, Brentford, Middx.

Springs for Large Diesel Engines. By C. E. Squire, M.Inst. Mech. E. London: Diesel Engine Users' Association, 56, Victoria Street, S.W.1. Price 7s. net.

Alternating Current Motors and Control Gear. By C. H. Claude Cooke. London: Crosby Lockwood and Son, Ltd., Stationers Hall Court, E.C.4. Price 3s. 6d. net.

Track Stress Report, November 1935–*November* 1938. Two Volumes. By W. E. Gelson and E. A. Blackwood. Calcutta: East Indian Railway Press. Price 16s. net.

Jane's Fighting Ships. 1939. Edited by Francis E. McMurtrie, A.I.N.A. London: Sampson Low, Marston and Co., Ltd., 100, Southwark Street, S.E. Price £2 12s. 6d. net.

Quartz Oscillators and their Applications. By P. Vigoureux, D.Sc. London: His Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 4s. 6d. net.

The Stressing of Locomotive Connecting and Coupling Rods. By George W. McArd. Epsom: Draughtsman Publishing Company, Ltd., 1, Links Road, Epsom, Surrey. Price 28s. net.

The South and East African Year Book and Guide. Edited by A. G. Brown. London: Union-Castle Mail Steamship Company, Ltd., 3, Fenchurch Street, E.C.3. Price 2s. 6d. net.

Jane's all the World's Aircraft. 1939. Edited by C. G. Grey and L. Bridgman. London: Sampson Low, Marston and Co., Ltd., 100, Southwark Street, S.E. Price £2 12s. 6d. net.

Mechanical Engineering Problems in Marine Transport

By STERRY B. FREEMAN*

TRANSPORT by water must always be the cheapest method since this medium is the densest. The whale moving in the water is heavier than the elephant moving on land and nothing heavier than the eagle and the albatross lives in the air to-day. The sea is the best and cheapest road; no mechanical problem is involved in keeping its surface renewed. As regards the ship, there are no tyres to wear out and the annual repair bills are not as heavy as they would be for road transport vehicles carrying the same tonnage over the same period. Necessary overhauling and repair work and any emergencies that arise are dealt with by the ship's own staff when they are not engaged as watchkeepers on the plant at work.

General Conditions.—Marine transport covers of course both passenger and cargo services and is carried on by passenger ships, passenger and cargo ships, cargo liners, and so-called "tramps." The demarcation between these different types is difficult to define. Their speeds are 25–32 knots for the express liner; 20–25 knots for the cabin liner; passenger ships, 16–20 knots; cargo liners, 12–18 knots; and lower speeds still for tramp ships and coasters. While the public desire the high speed and comfort that can only be obtained in large ships, these vessels have a number of limitations which result in correspondingly high charges and freight. Not only is the first cost extremely heavy, but the depreciation over about twenty years has to be paid for after a ship has lost her first and greatest earning power. Unless the ship is otherwise occupied, as in cruising, wide differences due to seasonal causes also increase costs.

Few dry-docks can take these very large ships; they cannot pass through the Panama and Suez canals, and unless government assistance is invoked,

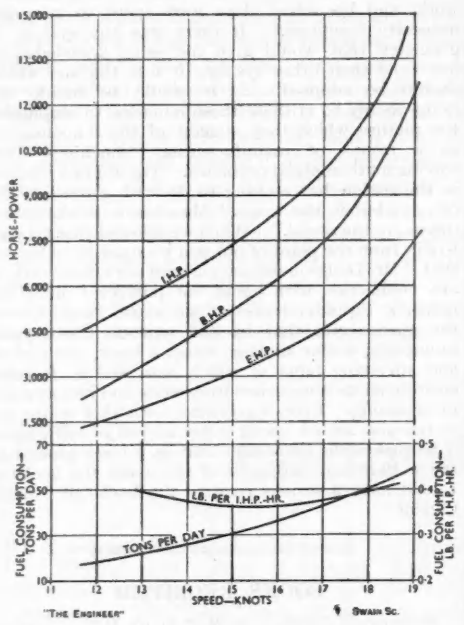


Fig. 1—*Horse-Power and Fuel Consumption Curves for Cargo Liner at Various Speeds*

their insurance is a difficulty. Separation of passenger and cargo traffic has become steadily more marked, and the very large ships carry practically no cargo.

The resources of mechanical engineering are being increasingly drawn upon by the great increase of care for human life and the addition of many amenities in the provision of elaborate food, shelter, heating, ventilation, air-conditioning, lighting, and precautions against the danger from fire. The machinery to provide these requirements includes such auxiliary plant as electric generators, motors, refrigerators, wireless stations, direction finders, depth sounding machines, motor boats, fans of various types, and so on. It is hardly possible to add further to the luxury already obtaining for years past in the upholstery of the furniture and fittings of the public rooms.

In addition to fulfilling every requirement as regards safety and accommodation, a new demand is made on the engineer in the matter of freedom from vibration. In the larger ships of the last generation, it was impossible to keep ink in the inkstands or to write letters in the accommodation at the after end of the ship; the vibration was too great. In modern ships, thanks to further stiffening of the structure and refinements in propeller design, this vibration bogey has been laid.

The weight of ships has been decreased by the use of special steels. This saving, together with the adoption of oil engines for propulsion or of turbines and water-tube boilers working at high pressure and superheat, has radically reduced the machinery space required, thus setting free large spaces for passengers' use and enjoyment. The elevators, swimming baths, cinema rooms, and the other equipment already described, add largely to the mechanical problems of the engineering staff.

The transportation of cargo is, however, the business of the majority of ships, and it is extraordinary how the world has been opened up in the past by small ships. For many services the small ship is often the right choice, and very large cargo ships are not necessarily so profitable. The provision of ships specially designed for a particular service, such as "sea trains" and "train ferries," has been of great assistance in facilitating and cheapening transport between certain points.

A modern ship carries special cargoes in addition to the bale and case or bulk goods in the holds. The fore peak and after peak tanks may carry highly valuable wood oil, and the double bottom tanks cargo oil of boiler or Diesel quality; these and the deep tanks, sometimes four, five, or six in number, are fitted with heating coils to maintain the necessary temperatures, and carry pea, bean, or palm oil, molasses, or latex. There may be small side tanks in the 'tween decks or poop for latex or oil. Then, one or two holds and their 'tween decks may be insulated for refrigerated cargoes. The holds in ships of Australian tonnage, fitted for the carriage of chilled beef, are designed to maintain temperatures within ½ deg. Fah. of a predetermined value, and are constructed to be gastight, so as to retain without serious loss the carbon dioxide gas injected to preserve the beef. The weather decks take railway rolling stock, long crane girders, big guns, &c., and each of these various types of cargo needs special care and expert handling. The provision and maintenance of suitable pumps, pump connections, steam heating coils and connections, refrigerating plant, all of the utmost reliability, is the engineer's work.

The design of coastal ships from 500 to 2000 tons and their mechanical equipment presents special problems, and the limitations of dimensions and of draught, with their effect on power and speed, obviously need special consideration. The raised quarter-deck type, fitted with machinery aft and having the large forward spaces clear, is commonly most suitable for coastal service with its frequent calls at ports and occasional heavy weather. The deck gear of those vessels carrying general cargo is usually considerable, and includes either cranes or derricks, one of which may be of 10 or 15 tons capacity. These winches will probably be steam or electrically driven, according as the ship is propelled by steam or oil engines.

Speed.—If the cost of the fuel were the only criterion of the speed at which marine transport should be carried on, there would be no justification for building ships to operate at speeds above 9 or 10 knots.

It is extremely difficult to estimate the value of speed. For passenger services, in these days of wireless telegraphy and telephony, it has generally no intrinsic value, and is just one form of luxury or sport. In cargo services the shipper wants his cargo delivered as soon as possible in order to receive early payment for his goods. Freights could be cheaper if shippers would be content with slower speeds. The number of voyages a ship on a regular schedule can make is a measure of the amount of cargo she can carry and money she can earn. Powerful machinery and the consequent high fuel consumption are, however, expensive (see Fig. 1), although they are fully justified if the additional speed enables the service to be carried on with fewer ships, or to attract cargo from other lines or forms of transport. Regularity is invaluable for ships running on a published schedule, and as delays in harbour and by weather upset the sailing times, a reserve of speed is necessary to make up lost time.

Cost.—The capital cost of propelling machinery and the necessary auxiliary machinery, together with the weight and space involved, is of primary importance in marine transport. The cost and weight of various types of marine propelling-machinery are compared in Table I. In each case the figures include the thrust block and shaft. For steamships, the boilers, superheaters, feed heaters, condensers, and auxiliaries necessary in using the main engines are included. For oil engines, four auxiliary oil engines all of the same type and power, forced lubrication, oil cooling and water cooling systems, pumps and coolers, air compressors and boiler operating on exhaust gas or with oil burner, are included. It will be understood that these figures are approximate, since so much depends upon specification, particularly as between steam reciprocating and turbine machinery.

TABLE I.—*Comparison of Costs and Weights of Various Types of Marine Propelling-Machinery*

Type of machinery	Cost	Machinery weight
Steam		
Triple-expansion reciprocating 220 lb. per square inch cylindrical boilers, saturated steam	100	100
Triple-expansion reciprocating 220 lb. per square inch cylindrical steam boilers superheated 560 deg. Fah.	110	102
Triple-expansion plus exhaust turbine superheated 560 deg. Fah.	135	97
Triple-expansion plus exhaust with reheat of high-pressure exhaust steam	120	102
Turbines, Parsons or Curtis, 220 lb. per square inch, cylindrical boilers 600 deg. Fah.	135	85
Turbines, Parsons or Curtis, 450 lb. per square inch, water-tube boilers, 750 deg. Fah.	140	75
Oil Engines		
Two-stroke, double-acting	140	95
Two-stroke, single-acting	147	100
Four-stroke, single-acting, supercharged	165	120
Four-stroke, single-acting	195	140

TWIN SCREW—RECIPROCATING—CARGO—PASSENGER—COAL BURNING
TWIN SCREW—TURBINE—CARGO—PASSENGER—COAL BURNING
TWIN SCREW—TURBINE—CARGO—PASSENGER—OIL BURNING
TWIN SCREW—TURBINE—CARGO—COAL BURNING
SINGLE SCREW—TURBINE—CARGO—COAL BURNING
SINGLE SCREW—RECIPROCATING—CARGO—COAL BURNING
SINGLE SCREW—TURBINE—CARGO—COAL BURNING
TWIN SCREW—FOUR-STROKE, SINGLE ACTING, AIR INJECTION—CARGO
TWIN SCREW—FOUR-STROKE, SINGLE ACTING, AIRLESS INJECTION—CARGO—PASSENGER
TWIN SCREW—FOUR-STROKE, SINGLE ACTING, AIR INJECTION—CARGO
SINGLE SCREW—FOUR-STROKE, SINGLE ACTING, AIR INJECTION—CARGO
RUNNING COST PER 1,000 MILES AT AVERAGE DRAFT—POUNDS
RUNNING COST PER MILE AT AVERAGE DRAFT—SHILLINGS
SPEED—KNOTS
"THE ENGINEER"
SWAIN SC.

Includes fuel, wages, victualling, stores, repairs, and upkeep.

Fig. 2—*Running Costs at Average Draught*

The number of voyages a ship on a regular schedule can make is a measure of the amount of cargo she can carry and money she can earn. Powerful machinery and the consequent high fuel consumption are, however, expensive (see Fig. 1), although they are fully justified if the additional speed enables the service to be carried on with fewer ships, or to attract cargo from other lines or forms of transport. Regularity is invaluable for ships running on a published schedule, and as delays in harbour and by weather upset the sailing times, a reserve of speed is necessary to make up lost time.

For a voyage the expense in fuel varies as the square of the speed, whereas daily expenses, such as victualling, wages and stores, vary as the reciprocal of the speed (Fig. 2). Consequently at high speeds the rate of increase in the fuel expense is greater than the rate of decrease in the other expenses. At low speeds the converse is the case, and some speed will be found at which the total of these costs will be a minimum. This is obviously the speed at which the ship should be operated on ballast voyages if other more important considerations do not arise.

Surveys.—Shipowners demand increased speed and at the same time increased economy. On the other hand, the Board of Trade and the classification

* Chief Superintendent Engineer, Messrs. Alfred Holt and Co. Institution of Mechanical Engineers, extracted from a paper written for the abandoned American meeting.

societies insist upon ever more thorough and comprehensive surveys to ensure complete safety for passengers and reliability of the ship and her machinery. Unquestionably these demands have spurred engineers to accept and use systems of power transmission, pressures, temperatures, materials, and methods of construction that they would not have risked empolying in past times when competition was not so keen. International competition in the shipping industry means that only those who comply with these demands can survive. The engineer must therefore increase the efficiency, and at the same time satisfy the surveyors, by increased economies.

Having decided which type of machinery will best suit the conditions of the route to be served, the next question is how best to keep the machinery in efficient condition. The rules and regulations of the authority under which the ship and machinery have to be surveyed for the maintenance of class, as being safe to carry passengers, and in good and efficient condition to carry dry and perishable cargoes, determine how often the plant must be opened up for examination. To ensure that this examination shall be of real value, so that any incipient defects may be discovered without fail, whilst at the same time avoiding penalising the ship by detention due to unnecessary elaboration of the survey, is a problem. A complete system of noting the wear and condition of both the main and the auxiliary engine and boiler details is essential, so that as wear goes on the necessary spare gear may be ordered and put in readiness for the time when it must be fitted. If ordered and fitted too soon, costs are unnecessarily increased. If ordered too late, the ship may be delayed.

Repairs. — Experience as to which types of machinery, steam reciprocating, steam turbines, or oil engines, need the greatest amount of renewal and repair, varies with the make of machinery, with the standard of supervision enforced, with the character of the engineers engaged in the work, and the service in which the ship is employed. A good engineer can do wonders with very inferior gear, whereas an incompetent engineer can quickly ruin the best installation that can be given him. At the same time, it must be recognised that inferior coal or boiler oil in steam ships, or fuel oil in motor ships, unsuitable lubricating oil, inferior packings and jointings, &c., can do damage beyond the power of the engineer to avert. Careful records of lubricating oil stocks are taken at the commencement and end of each voyage to check any possible wastage or excessive consumption. The sum of the consumptions of the various engines, auxiliaries, &c., is correlated with the amount of oil actually taken on board at the beginning of the voyage and that remaining at the end. The total oil on board includes that in the main engine drain tanks and auxiliary engine sumps and that in the storage tanks; oil retained in the engine systems is not included. All oil lost during the cleaning of drain tanks, sumps, &c., is shown in the consumption of the appropriate engine. Remarks on engine performance affecting the lubricating oil consumption, particulars of oil lost due to machinery defects, &c., are also recorded. A statement is furnished on each voyage if the oil is washed during separating process.

An example of the ratio of costs in a cargo ship and a passenger ship is given in Fig. 3 and Table II; it is of interest to observe how extremely small a part of the whole running cost is absorbed by the hull and machinery upkeep, deck, and engine stores.

Fuel and Its Effect on Mechanical Problems of Marine Transport.—Engineers are quite ready to use that prime mover which is right and most suitable for the purpose in view. In the larger ships a combination of different types is usually employed, for example, steam boilers and turbines for propulsion, oil engines to generate auxiliary power, and electric motors to operate isolated and distant units such as the windlass and the steering gear. In smaller ships the service to be performed will indicate whether steam or oil engines will best cover the whole of the requirements. Generally the voyage to be made is scheduled, and then the question of bunkers has to be faced. In ports such as Singapore and Suez, where there is no indigenous coal, the cost of imported coal is high in comparison with that in ports having a coalfield in the neighbourhood. If the length of the voyage makes it necessary to bunker *en route*, it will have an effect on the choice of fuel (see Table III). For equal weights, coal takes up about 17 per cent. more space than oil, and provides about 33 per cent. fewer heat units. Having decided on the fuel to be used, the right policy is to try to obtain the highest possible efficiency from each separate item of mechanical equipment in the ship. The adoption of higher speeds, better materials, and advanced design, helps to reduce weight and space, and as development goes on simpler forms and methods are evolved in order to arrive at the same results. Many different paths are being followed, and no standard engine has been developed to command such universal acceptance as, for example, the four-stroke-cycle motor for the automobile. The costs of the plain oil engine and of the plain steam engine propelling plant are now frequently equal, and owners desiring to build the simpler type of ship can adopt oil or coal with no additional capital expenditure.

In view of the fact that more than half the mechanically-driven ships in the world are fitted with oil engines, and few steamships are being built, it is of interest to examine the cause of the change.

The outstanding factors in deciding whether coal or oil should be used as fuel are the questions of bunker space and weight. In the majority of cargo ships, all available space is wanted for cargo purposes, and any weight in the bunkers shuts out a corresponding amount of freight. In mixed passenger and cargo ships there is the further disadvantage of delay and discomfort in bunkering coal. In the large fast passenger ship, with a rapid turn round at each end, coal is practically impossible. The oil-fired water tube boiler is a compromise, and with a cheaper class of oil for boiler use, the increased amount to be carried and burnt may be faced, since this oil can be carried in the double bottom and does not, as a rule, require special bunkers above the double bottom.

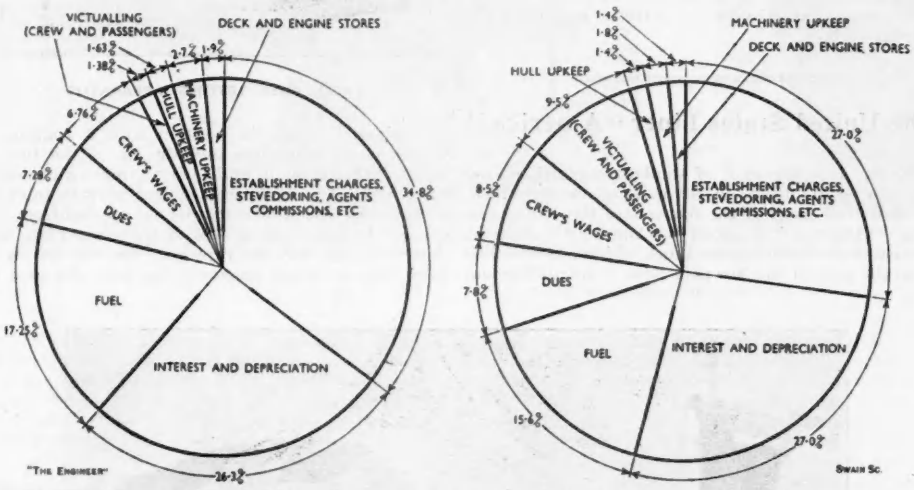
It can be ascertained whether the power required to drive a ship has been economically applied by the use of the so-called Admiralty co-efficient, $D^{\frac{2}{3}}S^3/h.p.=C$, and the fuel co-efficient, $D^{\frac{2}{3}}S^3/\text{fuel tons per day}=F$, where D is the displacement of the ship in tons, and S is the speed in knots, and h.p. is the horse-power. As the result of prolonged trials, both at sea and in tank tests, these co-efficients, in the hands of competent and experienced engineers, can be used to measure the efficiency of the ship and her machinery.

It is unfortunately the case that the indicators used to determine the power in steam or oil engine cylinders, and the torsionmeters used to record power passing through the shafting to the propeller, are not accurate to within say 5 per cent. The advent of higher pressures and temperatures has made the use of indicators still less satisfactory. The fuel co-efficient, which is based on the measurement of fuel, is more accurate than the Admiralty co-efficient, which is based on the measurement of power. These co-efficients are more useful as a means of comparison between performances of sister ships, or two performances of the same ship, than as a scientific measurement of the results.

Some figures taken from the experience of similar ships at similar displacements and speeds, but with different propelling machinery and fuel, are set out in Table IV :—

TABLE II—*Analysis of Operating Costs*

Item	Cargo liner of 10,500 gross rated tonnage, per cent of running cost	Intermediate passenger liner of 16,000 gross rated tonnage, 200 passengers, per cent. of running cost
Establishment charges, stevedorage, agents' commissions, &c.	34·80	27·00
Interest and depreciation	26·30	27·00
Fuel	17·25	15·60
Dues	7·28	7·80
Crew's wages	6·76	8·50
Victualling (crew and passengers)	1·38	9·50
Hull upkeep	1·63	1·40
Machinery upkeep	2·70	1·80
Deck and engine stores	1·90	1·40
Total running cost	100·00	100·00



Cargo liner of 10,500 gross rated tonnage Intermediate passenger liner 16,000 gross rated tonnage ; 200 passengers
Twin screw double-acting two-stroke engines, 16,000 b.h.p.; fuel consumption, 0·4 lb. per b.h.p. per hour

Fig. 3—*Analysis of Operating Costs*

TABLE III.—*General Particulars of Engine Economy Governing Marine Transport*

For the purpose of calculating the figures in the table, the following figures have been taken for calorific value of fuel, boiler efficiency, and mechanical efficiency :—

	Coal	Oil
Calorific Value of Fuel		
Available heat in fuel, B.Th.U. per lb.	15,000	19,000
Probable average value, B.Th.U. per lb.	12,500	18,000
Boiler Efficiency		
Cylindrical boilers, per cent.	65–75	77–82
Water-tube boilers, per cent.	75–80	87–88
Mechanical Efficiency of Engines		
Reciprocating steam, per cent.	90 approximately	
Oil engines, depending upon type, per cent.	72–88	

Type of engine	Overall thermal efficiency, per cent.	Fuel consumption, per s.h.p. per hr., lb.	
		Coal	Oil
Reciprocating engines using saturated steam	11	1·85	1·29
Reciprocating engines using superheated steam	13·5	1·50	1·05
Reciprocating engines having the exhaust steam from high pressure reheated	16	1·27	0·88
Reciprocating engines and exhaust turbines using superheated steam	16	1·27	0·88
Turbines and gearing working at low pressures and temperatures	16	1·27	0·88
Turbines and gearing working at high pressures and temperatures and using oil-engine-driven generators for auxiliary power	24–27	—	0·57
Oil engines with air injection of fuel	35	—	0·40
Oil engines and airless injection of fuel and high maximum pressure	40	—	0·355
Oil engines with waste-heat boiler	37	—	0·380
Oil engines with heat recovery on Still system, or with abnormally high compression pressures	43	—	0·330

TABLE IV.—*Comparison of Performances of Similar Ships*

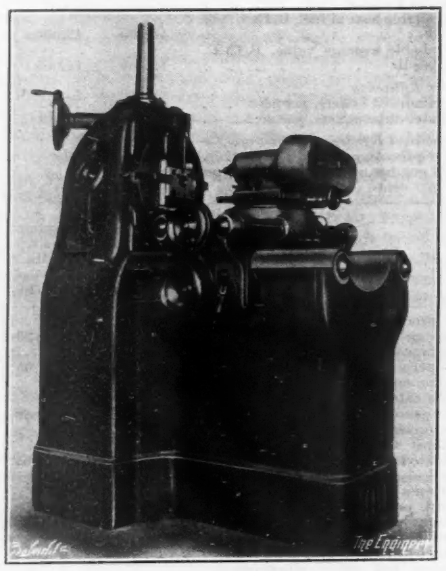
Machinery	Fuel	Admiralty coefficient	Fuel coefficient	Fuel per s.h.p. per hr., lb.
Triple-Expansion Reciprocating Engine				
Saturated steam	Coal	300	15,000	1·85
" "	Oil	300	21,500	1·29
160 deg. Fah. superheated steam	Coal	300	18,600	1·50
Ditto	Oil	300	26,600	1·05
Reheat engine	Coal	300	22,000	1·27
Reduction Geared Turbine				
200 deg. Fah. superheated steam	Coal	300	22,000	1·27
Ditto	Oil	300	32,000	0·88
High pressure	Oil	300	49,000	0·57
Oil Engines				
Four-stroke cycle air injection oil engine	Oil	300	70,000	0·40
Two-stroke cycle airless injection oil engine with exhaust gas boiler	Oil	300	74,000	0·38

Triple or quadruple expansion reciprocating engines, supplied with steam at about 220 lb. per square inch from tank boilers, are still being built for steamships of moderate power; the addition of an exhaust steam turbine has been quite usual in several fleets of the cargo liner class. Such engines are usually partially balanced, and weight is reduced by the use of higher revolution speeds than were formerly considered acceptable with single screws. The use of steam superheated up to a total temperature of 560 deg. Fah. has encouraged the adoption of a variety of valve systems which do not require the

use of so much lubricating oil, and which give a sharp cut-off without affecting the exhaust when running at less than full power. In spite of efficient valves, superheating, and an exhaust turbine, such reciprocating engines cannot better the performance of the turbine and are more complex.

Geometric Jig Borer

THE following tables give some particulars of the "geometric" jig borer made by the Meyer Mechanical Laboratories of San Francisco. The firm of E. H. Jones (Machine Tools), Ltd., has recently been made sole agent in this country for the supply of



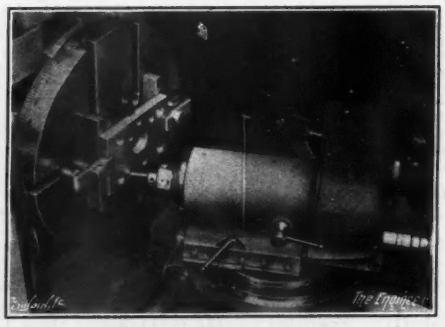
GEOMETRIC JIG BORER

these machines, one of which is illustrated in two engravings.

Particulars of Boring Machine.

Rotary Table—	
Diameter	14in.
Working Surface	154 square inches
T-Slots	Three $\frac{5}{8}$ in.
Swing over bed (table on centre)	24in.
No. speeds of rotation (power)	4
Speeds	30, 78, 170, 437 r.p.m.
Drive	Vee belt
Table graduated	360 deg.
Vernier reads	5in. of arc
Hand wheel rotary adjustment	Yes
Taper of hole in spindle	$\frac{5}{8}$in. per foot.
Size hole through spindle	$1\frac{1}{2}$in.
Range—	
Vertical measuring range, rotary table head	10in.
Horizontal measuring range, boring spindle	16in.
Rectangular capacity (centre distances of holes)	10in. × 16in.
Hand boring feed range of carriage	18in.
Hand boring feed rate of carriage	1in. per turn of handwheel
No. power feeds, carriage	5
Carriage feed range	$\frac{1}{4}$in. to 3in. per min.
Swivel adjustment of compound	360 deg.
Compound feed range, by hand for angular holes	5in.
Spindle—	
No. of speeds	10 in geometric progression
Speed range (standard)	294 to 2350 r.p.m.
Drive	Vee belt
Boring capacity—tool steel	3in. dia.
Collet capacity of spindle	$\frac{1}{2}$in.
Taper hole in spindle	No. 3 Morse
Size hole through spindle	$\frac{1}{2}$in.
Measuring Screws—	
Counters read to	0·01in.
Diameter of micrometer dials	6in.
Micrometer dials graduated to	0·001in.
Micrometer dial verniers graduated to	0·0001in.
Dimensions—	
Height overall	68in.
Length	48in.
Width overall	38in.
Floor space	38in. × 48in.
Height of spindle above floor	45in.
Height of carriage ways above floor	34in.
Motors—	
Rotary table drive	1/2 H.P.
Boring spindle	1/3 H.P.
Feed	1/20 H.P.

The machine is intended for precision tool room work. That fact makes it unnecessary for us to refer to such details of construction as the necessarily sturdy frame, the use of pre-loaded roller bearings, &c. We may pass at once to a study of those qualities which are the distinguishing features of the machine. On this jig borer all measuring is done on the machine itself by the use of precision screws and large 6in. micrometer dials and verniers. The precision measuring screws are made of tool steel hardened to 53–56 Rockwell "C" scale and are ground and lapped. The Acme threads are accurate in lead to a maximum error of 0·0001in. per inch of length; the maximum lead error between two points at the 16in. cross measuring screw is 0·00025in. and on the 10in. vertical screw 0·0002in. Since the screws are used only for measuring and since the compound and rotary table head are clamped in position by self-equalising clamps when boring there is very little wear of the screws, and in fact it is claimed that tests have shown that accuracy is maintained throughout years of use. When starting a job, vertical and cross measuring counters and the micrometer dials are set at zero, thus establishing two base lines at right angles from which all measurements are made. To measure a certain distance the operator watches the counter until it measures the correct amount to one hundredth of an inch. The micrometer dial reading in thousandths and the vernier in ten-thousandths then permit the final adjustment to be accurately made. Besides straight boring the machine is capable of boring at any angle. The table is graduated to 360 deg. and the vernier permits of adjustment to an accuracy of 5 minutes of arc. One of the accompanying engravings shows angle boring in process. Taper boring and the boring of large holes is performed with the spindle locked and the rotary table power driven.



ANGLE BORING IN PROCESS

This jig-borer also makes an excellent measuring machine and it is said that in some large tool rooms it is used for that purpose alone. A surface plate supplied with the machine rests directly on the ways and upon it can be placed dial indicators and other inspecting devices. By the use of the surface plate it is also possible to perform lay-out work expeditiously.

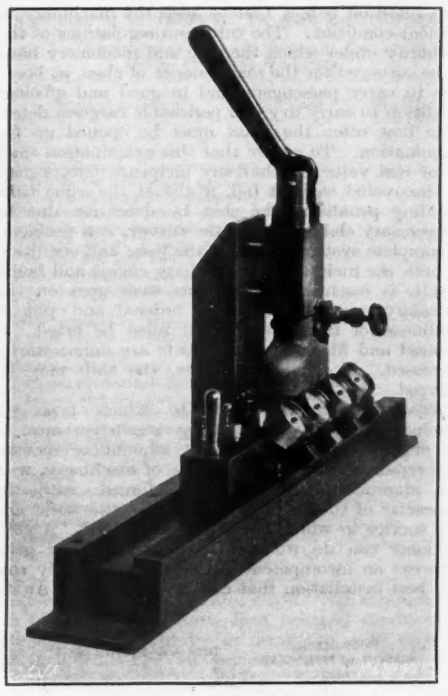
The United States Liner "America"

IN the annual review of shipbuilding and marine engineering, published in our issue of January 19th, we described some of the features of the twin-screw liner "America" designed for the North Atlantic service of the United States Lines, which was launched from the yard of the Newport News Shipbuilding and Dry Dock Company, Ltd., of Newport News, Va., in August last, and is now being fitted out. The accompanying engraving shows the forward funnel and mast with the crow's nest, after they had been stepped into place at the fitting out berth of the Newport News Yard. The design is squat and is specially shaped in order to deflect the smoke, and prevent it reaching the sports deck below. One of the two funnels is a dummy and is to be used to house the emergency generator, switchboard, and equipment. It may be recalled that the new liner has an overall length of 723ft., a beam of 92ft., and a depth to "A" deck of 45ft. She will be designed to carry about 1219 passengers and a crew of 639. Her gross tonnage will be about 30,000 and she will be propelled by twin-screw geared turbines having a designed output of 17,000 S.H.P., the propeller speed being about 128 r.p.m. The height of the funnel above the bottom of the keel is 130ft.

FORWARD FUNNEL AND MAST OF U.S. LINER "AMERICA"

Shell Fuse Testing

A CERTAIN type of shell fuse which is at present being produced in this country is fitted with a small copper cover plate or sealing disc. For this purpose the nose portion of the fuse is recessed to take the



SHELL FUSE TESTING APPARATUS

disc which is fitted in position with a coating of shellac round the edges and the tip of the fuse is then rolled or spun on to the plate to make a pressure-tight seal. The fuses are required to withstand an air pressure test of 30 atmospheres, applied from the outside, to prove an air seal at the cover plate and that the plate will not rupture. For the testing of these fuses a special apparatus has been designed by B.E.N. Patents, Ltd. This apparatus is claimed to be particularly economical in the amount of air used, rapidly and easily operated, and suited to the type of unskilled female labour invariably utilised in this class of work.

The arrangement of the machine, as may be seen in the accompanying engraving, consists generally of a cam-operated vertical column to which is attached the pressure head carrying high pressure air and which is connected to an air receiver by a length of special flexible air hose and a hand-wheel valve. The pressure head, which may be arranged to test either one or two fuses per operation, carries one or more internally coned sealing rings which are arranged

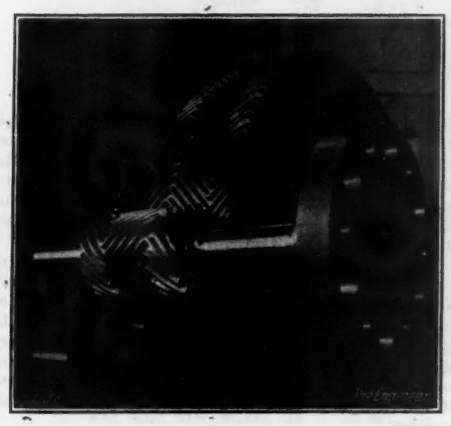
with a taper similar to that of the fuse cap so that when the cam lever is pulled downwards, the coned rings fit closely on the nose of the fuse and make an effective air seal.

The bed of the machine is arranged to take a sliding magazine carrier accommodating 2, 4, or 6 fuses so that they can be readily moved into position beneath the pressure head for each test operation. The fuse magazine has an independent relief valve and pressure gauge for each fuse carried; these gauges are large-scale low pressure type instruments, inclined at a suitable angle to enable them to be easily read by an operator.

In loading the magazine each fuse is dropped on to a formed composition locating ring which effects an air-tight seal when the pressure head is pulled down to the testing position. Spare fuse magazines are supplied to speed up the work, one operator loading and unloading the magazine while a second operator carries out the actual testing. The machine illustrated is known as the "Duplex Bench Tester" with a four-magazine holder arranged for hand operation. Machines can be supplied for foot-operation in single or duplex form with one or more magazines.

Helical Gearing for a Mine Winder

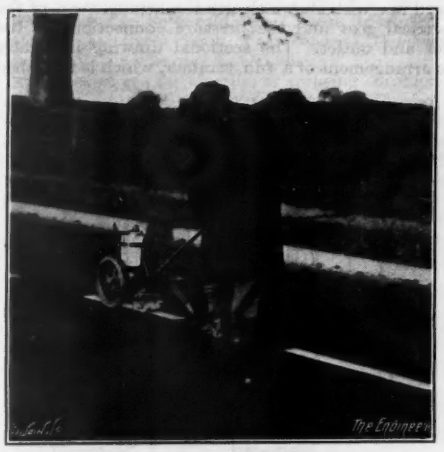
THE photograph reproduced in the accompanying engraving shows an imposing pair of triple helical gears which have recently been completed by David Brown and Sons (Hud.), Ltd., Huddersfield, for a winder in a South African gold mine. The gears, which weigh 25 tons, are designed to transmit a maximum load of approximately 6000 H.P. The cast steel wheel is nearly 16ft. in diameter and is made in halves to facilitate handling and assembly on site, while the pinion is integral with its shaft and is cut from a forging of high tensile steel. The high steel coupling is also of interest, as it is 56in. in diameter and is bored 16in. diameter to accommodate tangential folding keys.



MINE WINDER GEARING

Road Line Marker

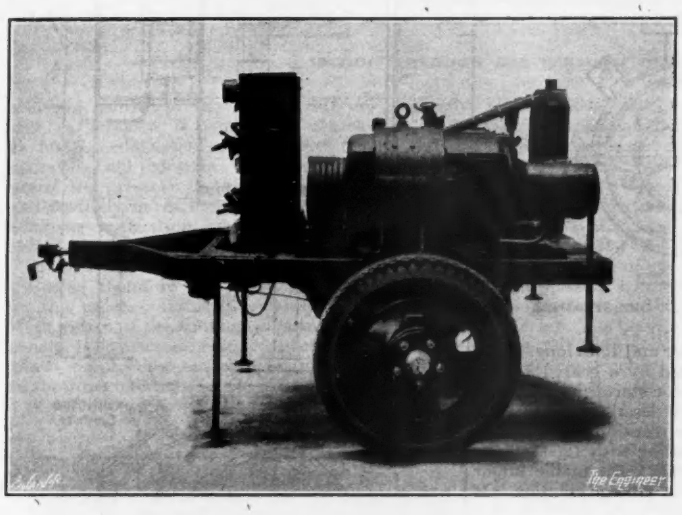
THE accompanying engraving shows the "Invicta" road line marker made by Aveling Barford, Ltd. of Grantham. Paint carried in the container visible in the engraving is gravity fed to the marking roller through rubber tubes connected to the distributor header. When the paint applying roller is lifted clear of the road, paint control bars fitted across the feed tubes came into operation and the flow of paint is stopped. This arrangement is particularly advantageous when painting "broken" lines because the flow of paint is controlled simply by raising or lowering the operating handle. The control bars are adjustable and can be fixed in such a position that the flow of paint is regulated in accordance with the nature of the road surface. The setting of the bars is effected by a knob at the top of the handle operating a cam and visual evidence of the setting is provided by a pointer. A second rubber roller in contact with and rotated by the paint applying roller ensures even distribution of the paint. So that the device may be used for painting kerbs provision is made for raising one wheel in relation to the other. It is claimed that this road line marker will do work equivalent to that of six men applying paint by hand.

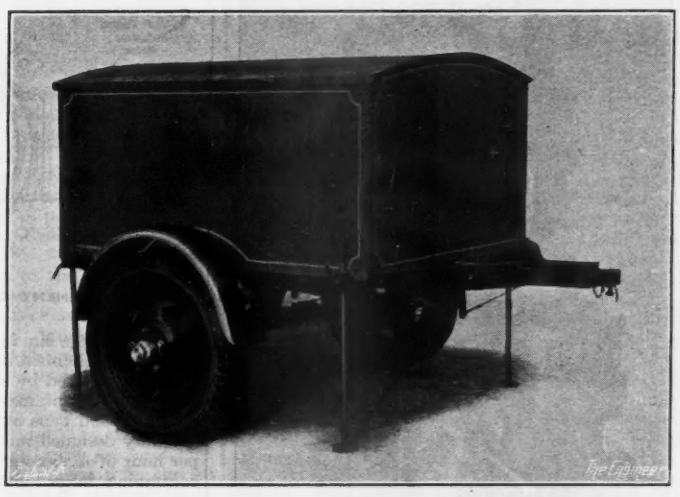


ROAD LINE MARKER IN USE

The paint container has a capacity of 1 gal. Rollers are made of sponge rubber suitable for facing a 4in. line. Three rollers are provided with each machine, each of a different diameter and suitable for smooth, medium, and rough surfaced roads. The device has the following dimensions:—

Wheel centres, 12⅜in.
Overall width, 16½in.
Length, without handle, 15½in.
Height, without handle, 20½in.
Height to top of handle, 2ft. 7in.





18-kW PORTABLE GENERATING SET

A Portable Power Plant

THE portable A.C. generating unit shown in the accompanying illustrations was designed by the manufacturers, H. E. Nunn and Co., Ltd., and Crompton Parkinson, Ltd., supplied the alternator. For auxiliary lighting or power work the set has many uses, for single or three-phase current can be derived from the switchboard to be seen on the left. The output of the unit is 18 kW or 22·5 kVA at 0·8 power factor; the pressure 400/230 volts and the frequency 50 cycles. In the case of a large works the output is sufficient for emergency lighting or the permanent lighting of a section of the works. For smaller establishments, the output might prove quite adequate for all normal requirements. The makers point out that in some places it may be more efficient to derive the night demands for light and power from such a plant rather than from the main generating set.

It will be seen that the unit is mounted on a truck carriage and may be used for A.C. welding or for operating portable electric tools on remote constructional jobs. In war time the set can serve as standby to be brought into operation on the failure of other plant or a public supply.

Normally the petrol engine is a V 8 unit with the cylinder block cast integrally with the upper half of the crankcase and with a thermostat-controlled radiator and is belt-coupled to the alternator. The unit's general usefulness is increased by the fact that it can be operated with petrol or coal gas, including gas under pressure in cylinders where no gas main is available. Since the unit is entirely under cover it is completely stormproof. Under operating conditions clamp type Jacks can be let down to give it a rigid support. The overall length is just under 8ft. and the width 5ft. 6in. The popularity which the set is acquiring can be gauged from the fact that a contract running into hundreds of 18 kW generators has been placed with Crompton Parkinson, Ltd.

Concrete Deterioration and Repair

THE unfortunate frequency of deterioration in concrete structures was the subject of a report to the American Railway Bridge and Building Association, and the explanation of this condition was attributed to a multiplicity of causes. But of a score of causes, practically all relate to either materials or workmanship. Probably the most disruptive agency is occluded water, especialy where low winter temperatures prevail. Distinction must be made, also, between damage owing to weathering of exposed surfaces and that because of water seeping through from the rear surface buried in earth. In the latter case the extent of damage varies according to the density of the concrete. As to remedy or repair of the numerous and various methods used, practically all can show records of success and failure, which shows the importance of local factors and conditions. For waterproofing the rear surfaces which are to be covered in embankments, some form of asphaltic treatment is the most general, applied either as a paint or a mortar, and often with sand or some fibrous material added, and layers of felt added to form a membrane. Cement grout is also used, either in the ordinary way or applied by compressed-air jets and machines. In many cases of patching deteriorated surfaces an iron treatment is applied in the form of a grout, especially where an extensive amount of new concrete is to be applied to a surface after thorough cleaning. Asphalt and cement paints as surface protection have been used, as well as ordinary paints which are applied after the cleaned surface has been well soaked with tung oil. It is essential to prevent shrinkage of the new concrete, and also to give careful attention to its complete curing. For large surfaces it is best to apply the concrete by the pneumatic process, or to place forms and apply the concrete as in new construction. In the latter case, the use of vibrators is recommended.

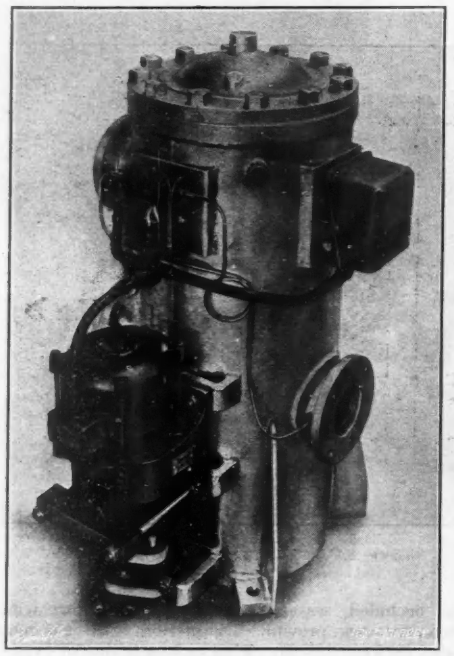
GLUE FROM SULPHATE LYE.—A note in the *Swedish Export Journal* says that a process has been developed in Sweden by which a new form of glue is made from the large quantities of waste lye from the Kraft paper mills. Known as "Sulfo Glue" it is said to be a serviceable substitute in many cases for animal and vegetable glues, one advantage being that it does not turn mouldy or sour in the prepared state. It is also mentioned that glue is sold under the name of "Sulfo Plastic," which is a mixture of the glue with chalk or other material. This preparation is obtainable in different colours and lends itself to stucco patterns of the most durable description, being applied without any preliminary preparation of the surface.

Motor-Driven Strainers

FOR many industrial purposes, marine oil engines, and turbine machinery strainers for fuel oil and other liquids have proved to be not only economical but also essential to the correct operation of the plant and to the prevention of unnecessary wear. We illustrate in the accompanying engravings two new designs of strainer made by Auto-Klean Strainers, Ltd., the one supplied for dealing with impregnating oil used in the manufacture of electric cables and the other suitable for straining viscous liquors. Each is of large capacity and provided with motor drive to the cleaning mechanism.

In designing strainers for use in connection with unusual and difficult duties, the firm considered that the success of its hand-operated strainers in normal fields warranted an extension of their uses to large-scale straining duties, in which completely automatic operation would be desirable. A complete range of such strainers was accordingly designed, and in the accompanying half-tone engraving and in a sectional drawing are shown the main constructional features of a typical "Lolos" strainer of this range. This particular unit is stated to be one of many supplied for handling cable impregnating oil.

The straining element is basically the same as in the "Lolos" hand-operated units, but the body is fabricated and incorporates a steam jacket to maintain the oil at a suitable temperature and viscosity. The straining element is a cylindrical cartridge with



STRAINER FOR CABLE OIL

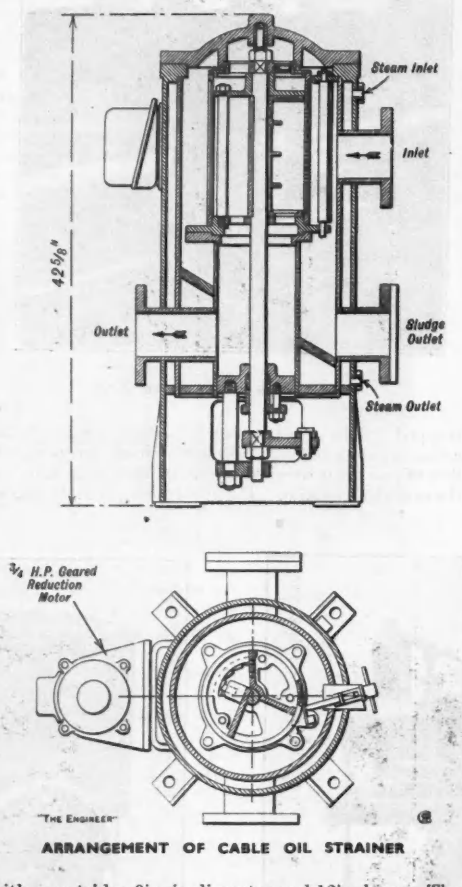
longitudinal ribs on its outer surface, externally threaded and wound with wire. For lubricating oil the usual spacing between the wires is 0·005in., and for Diesel fuel oil 0·003in., but strainers are made with other spacings and may be as fine as 0·0005in. Of course, the fineness of straining is determined by the diameter of the wire and the number of threads per inch.

Solid matter retained by the strainer lodges on the surface of the cartridge and tends to choke the passages between the wires, causing the difference of pressure between the inlet and outlet to increase. On the hand-operated strainer, to remove the dirt, a handle is worked, rotating a vane inside the cartridge which, acting as a semi-rotary pump, forces a supply of cleaned oil through the wires in the reverse direction of flow. A ratchet, usually placed at the bottom of the central spindle, rotates the cartridge during the pumping stroke, carrying the dirt on to an external fixed scraper blade which picks up the dislodged dirt and drops it into a sump. This process is assisted by the direction of the flow of the incoming oil.

In the motor-driven "Lolos" strainer the cleaning mechanism is operated by an electrical motor automatically controlled by a differential pressure control switch. The switch unit consists of a mercury tube linked to a pair of flexible metal bellows. One bellows is connected to the inlet or "dirty" side of the strainer and the other to the outlet or "clean" side. A pressure rise on the inlet side or a fall on the outlet, caused by the strainer choking, results in a movement of the bellows and operates the mercury switch to start the cleaning motor. The motor runs until the strainer is clean and any excess pressure is dispersed; the bellows then return to their normal position and the mercury switch stops the motor.

Range adjustment is provided to compensate for the normal pressure loss across the strainer, and a differential adjustment enables the cut-in and cut-out pressure to be accurately controlled. These adjustments are made on site under working conditions and once set need not be altered.

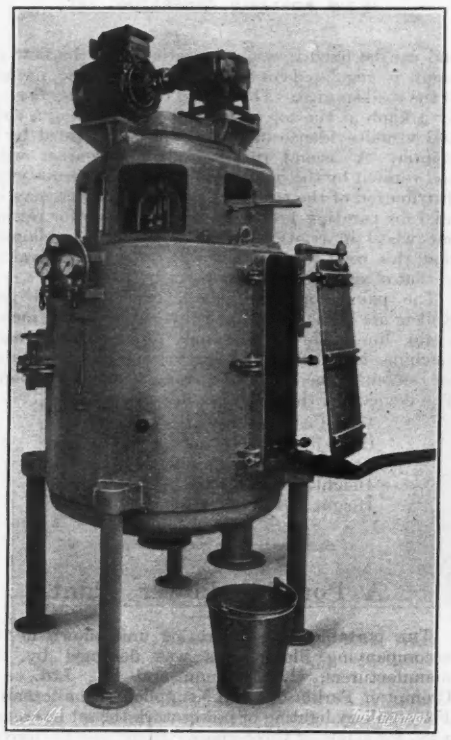
The photograph of the "Lolos" strainer reproduced herewith shows clearly the arrangement of the electrical gear and the pressure connections to the inlet and outlet. The sectional drawing illustrates the arrangement of a 4-in. strainer, which is furnished



ARRANGEMENT OF CABLE OIL STRAINER

with a cartridge 9in. in diameter and 12in. long. The cleaning mechanism is operated by a geared ¾-H.P. motor, controlled by a contactor starter switch, and, of course, the automatic switch described.

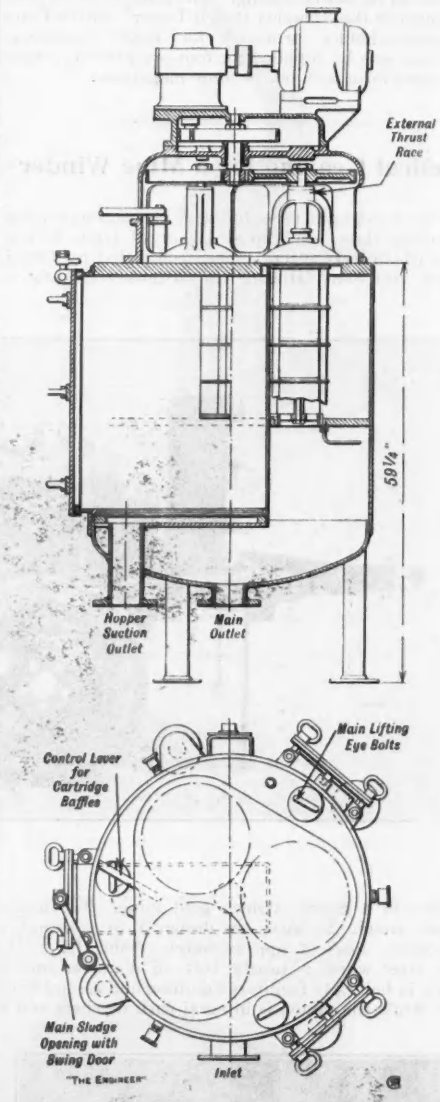
The second type of strainer mentioned above is a specially designed unit for dealing with 1200 gallons per hour of a viscous and highly inflammable liquor containing large quantities of foreign matter. It



STRAINER FOR VISCOUS LIQUORS

works on the "Auto-Klean" principle which is probably well known to our readers. Briefly the "Auto-Klean" element consists of a pack of hollow plates, between each of which is a cleaning blade threaded on to a fixed rod. The hollow plates are mounted on a spindle so that they may be rotated by external means, thereby scraping out the slots. The oil or other liquid flows inwardly from the periphery of the cylindrical pack of plates and up through the element to the outlet of the strainer.

In the new design of motor-driven strainer three elements, each 5·7in. in diameter and 18in. long, are disposed within the casing as shown in the drawing. The elements are continuously rotated through reduction gearing by the driving motor. The driving motor is rated at 1 H.P. and is of the Lancashire "Fankuld" flameproof type. It drives the elements at a speed of 2·8 r.p.m. through Opperman reduction gearing. As the elements rotate, dirt is removed by the cleaning blades and deflected by suitable baffles to a hopper built into the body. The baffles can be closed by operating an external lever before emptying the hopper, to prevent rejects falling back into the body. A perforated floor is fitted to the hopper with the object of avoiding waste of liquor during the operation of removing rejects through the main



ARRANGEMENT OF VISCOUS LIQUOR STRAINER

sludge opening. By means of this arrangement, when straining is finished the baffles are closed and the main pump suction changed over from the strainer outlet to the connection provided on the underside of the strainer, communicating with the hopper, so that the liquor is drained from the hopper and the rejects are practically dry when removed.

The firm brings to our attention an advantage of motor-driven strainers which might be overlooked. Not only are they suitable for unusual duties, such as described above, but they can be installed with advantage in circumstances in which the ordinary hand-operated unit would be suitable, if it were not for the inconvenient layout of pipe-lines necessary to bring the hand-operated unit into an accessible position.

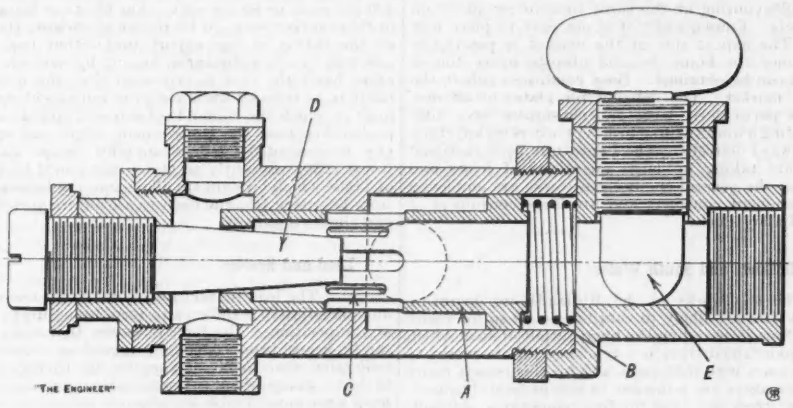
Running Petrol Engines on Coal Gas

THE conversion of a petrol engine to run on town's gas presents little difficulty; in fact an open gas pipe held in the air intake of the petrol carburettor is sufficient to keep the engine running. The difficulty lies in obtaining a gas mixer with a single control that will give the maximum power and economy at all engine speeds, and that will cut off the gas supply completely when the engine is stationary.

We are indebted to the British Gas Federation for particulars of one type of mixer that fulfils these conditions. It is shown in the accompanying

drawing. The suction of the engine moves the piston A against the spring B. Air may then enter through the slots C, and gas through the annular space between the cone D and the piston. The cone is provided with an adjustment so that it can be set to give mixtures of different air-gas ratio and to allow for district variations in gas quality. It will be noted that withdrawing the cone enriches the mixture. The throttle E is provided with a screw adjustment to give accurate and fine control, but can be replaced by a simple butterfly valve for rapid operation.

The carburettor was designed primarily for running-in engines after assembly. The first essential feature of this process is that the engine is run at a low speed with no load in order to bed down the moving parts. Gas is very suitable for this purpose, for at low speeds



SECTION THROUGH GAS CARBURETTOR

accurate control of the fuel-air mixture is possible and carburetion is complete, whereas on petrol at low speeds vaporisation is incomplete and the operating efficiency is very low. Secondly, with petrol the presence in the exhaust gases of unburnt and partially burnt fuel necessitates the provision of adequate ventilation, while unnecessary wear of the cylinder walls occurs because the unvaporised petrol tends to remove the protective oil film.

Gas is therefore technically preferable to petrol for this process, and it is certainly more convenient. With petrol, if the running-in is to be done on a test bench, it is necessary to connect the engine to a petrol supply—for example, an overhead tank. If, on the other hand, the engine is mounted on the chassis it is usually necessary to carry petrol to it in cans,

GAS BAG ON ROOF OF A LORRY

both methods involving some inconvenience and some danger of fire. If gas is used it is possible, with sufficient gas points round the walls, to connect any engine whether in a chassis or on the bench, quickly, easily, and safely to the fuel supply.

Economically gas represents a cheaper method of running-in than petrol. With gas having a calorific value of 500 B.Th.U. per cubic foot, 220–250 cubic feet are equivalent to one gallon of petrol which, at the domestic gas rate, compares with petrol at 1s. per gallon. It must also be remembered that gas is a non-knocking fuel so that high compression engines can be run-in without the necessity of providing expensive high-grade spirit.

After running-in light, some operators prefer to apply load gradually until the engine develops about two thirds its maximum power in order to complete the bedding down process. The power developed by a petrol engine running on gas is always slightly lower than on petrol, owing mainly to the reduction in volumetric efficiency when running on gas, but other factors have to be considered. Those interested are referred to Pye's book *The Internal Combustion Engine*, Vol. 1, Chapter 5, Art. 36.

The use of gas for traction is arousing considerable attention in view of the present petrol rationing scheme. The carburettor previously described is suitable for traction purposes on small engines, since it is capable of developing up to 18 B.H.P. For horse-powers greater than this figure, larger carburettors are available.

The loss in power in a petrol engine converted to gas has already been referred to; this loss cannot be compensated unless the compression ratio of the engine is increased, which is not usually practicable. The loss, however, should not exceed 12 per cent. of the maximum power on petrol—not a serious inconvenience. The gas consumption under power of a converted petrol engine is between 25–30 cubic feet per B.H.P., and a gallon of petrol is equivalent to between 220–250 cubic feet of gas.

The storage of gas on the vehicle may be either in high-pressure cylinders fitted to the chassis, or in a low-pressure gas bag attached to the roof of the vehicle. The high-pressure system unfortunately does not lend itself to rapid development in the present emergency, owing to the capital outlay on the necessary compression plant, and other specialised equipment. It is therefore certain that the low-pressure gas bag will once again make its appearance. The volume of gas which can be stored by this method, however, is limited, and generally the gas contained in the largest bag that can conveniently be carried by a vehicle represents a distance of between 10–20 miles. For town work, such as goods delivery, this milage is adequate, for sufficient filling stations to meet normal requirements could readily be made available. The cost of running on gas should be lower than on petrol, and marked economy is obtained on slow running; furthermore, starting on gas is very much easier than on petrol. In the accompanying half-tone engraving one of the Gas, Light, and Coke Company's vehicles fitted with a gas bag on the roof is illustrated.

Canadian Engineering News

(By our Canadian Correspondent)

Economic Conditions

In Canada, as elsewhere, important changes are taking place in the character of business, but with less disturbance than at the outbreak of war in 1914. The shifts are now also more extensive, for one reason because the national economic structure is much larger (and, incidentally, much stronger) than on the last occasion of a clash in Europe. The fact should be stressed, however, that a year's respite from war gave political authorities and business and financial executives time to design plans to readjust their operations to the changes consequent upon war. In fact, the measures now being taken are patterned upon those developed during the 1914–1918 period which provided ample protection to the national economy, while allowing the fullest possible scope for private enterprise. Of particular note is the prospective wide expansion in exports of manufactured goods, foodstuffs, base metals, &c., to Great Britain and her allies, and it is generally felt that the Dominion is entering upon a period of intense industrial activity. Indicative of war preparations is the fact that steel mill operations were accelerated in August when 122,019 tons of steel ingots and castings were produced, compared with 111,419 tons in July and 82,871 in August, 1938. Pig iron output advanced to 69,520 tons from 59,587 in the previous month and 49,477 a year ago. Output of ferro-alloys at 3313 tons was little more than half the July total of 6475 tons, but was almost double the 1857 tons reported for August, 1938. Stepping up of industry is reflected in the output of central electric stations which produced 2,291,425,000 kW hours during August as compared with 2,205,189,000 in July and 2,075,000,000 in August last year. At present fourteen plants in the Dominion are turning out aircraft and parts, most of them working on orders for both the Canadian and British Governments. It was recently announced that in the matter of motorised traction Canada's automobile factories are well equipped to produce whatever the Government might require. For some years they have themselves been experimenting on this sort of thing, and the Government has from time to time tried out their vehicles. No standard type of motorised equipment had been decided upon before the crisis developed, however.

Pulp and Paper

British Columbia's pulp and paper industry, representing an investment of $50,000,000 with an annual production valued at more than $12,000,000, stands to gain from the war's removal of German competition and reduction in Scandinavian exports. German and Scandinavian pulp and paper have provided serious competition for British Columbia mills in the past in the United States market, and further afield. So far as newsprint is concerned, British Columbia companies are likely to benefit most from elimination of German sales in the Orient. Pulp makers are expected to gain chiefly in the United States market by restriction of the unsettling price influence of Scandinavian stocks. British Columbia pulp's two mills, at Woodfibre and Port Alice, are now in operation, and if curtailment of European competition has the expected effect they will remain in production indefinitely, producing bleached sulphite.

B.C. Mill Expansion

Expansion of the British Columbia Plywoods, Ltd., plant on the Fraser river by the addition of an entirely new unit, making the enterprise the largest of its kind in Canada with a production ranking with that of the largest plywood companies on the Pacific coast, has been announced. Approximately 300,000 dollars is being spent now on establishment of the new plant, which will be in operation by next February. The necessary machinery has already been ordered, including equipment for an additional power plant. The new plant will concentrate on production of plywood by the so-called hot-press process which effects permanent water-proofing. The company's existing plant, employing 300 men on three shifts, is already the largest in British Columbia. The new unit will add at least 100 men to the company's pay-roll.

New Chlorine Factory

Owing to increased activity in the newsprint and textile industries a new chlorine plant, recently completed by Canadian Industries, Ltd., is to be placed in operation shortly. In order to round out this unit of the company's alkali division the erection of a caustic soda finishing plant is being undertaken, and ground has already been broken for this portion of the works. Construction will be pushed forward as rapidly as possible with the expectancy that it will be ready for operation by the early spring. The new section will be a one-storey building occupying an area of 126ft. by 180ft., with a reinforced concrete foundation, structural steel and brick superstructure, a light-weight concrete roof with steel sash, and radial brick chimney. Company officials estimate that the cost of the extension with equipment will be in the neighbourhood of 400,000 dollars.

New Electric Furnace

An elevator type of electric furnace for the annealing of silicon transformer core punchings has recently been installed in the Davenport Works of the Canadian General Electric Company, Ltd. This furnace is rated at 135 kW, 200 volts, 3-phase, and has overall dimensions of approximately 9ft. 6in. wide by 10ft. 9in. long by 16ft. high. The total weight on the footings, including a loaded car, was estimated to be 28 tons. The heating chamber is a box type furnace lined with 4½in. of semi-refractory firebrick backed with 10in. of insulation. It is 63in. wide, 8ft. 6in. long, and 42in. high to the spring of the arch, the roof being of brick arch construction. The opening through which the car rises is 54in. wide by 7ft. 9in. long. The heating units are flat, ribbon wound in sinuous loops, and mounted in three rows on each side of the furnace and one row near the bottom of each end. A typical load of power transformer core steel handled by the furnace weighs about 8000 lb., which, with the hearth plates, makes a total load of about five tons, and entails a power consumption of about 1630 kW hours to bring the load to a minimum of 800 deg. Cent. The annealing is done with a neutral atmosphere in the furnace to prevent oxidation. This atmosphere is provided by a 200 cubic foot combustion type atmosphere controller, manufactured by the company.

THE LATE MR. G. D. HARDIE.—We regret to have to record the death on February 2nd of Mr. Gordon D. Hardie, who for seventeen years had acted as grinding wheel representative of the Carborundum Company, Ltd., for the Glasgow area.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

New British Export Prices

Following the advance in the British home trade prices on February 1st, announced in the Control of Iron and Steel (No. 6) Order, the export prices were also increased. Merchant bars over 3in. were advanced by £1 to £13 2s. 6d. f.o.b. and bars under 3in. by £1 4s. to £13 9s. f.o.b. Angles, four united inches and under, and channels 3in. web and under, were increased by £1 4s. to £13 13s., and tees, four united inches and under, by the same amount to £14 8s. f.o.b. Angles, tees, and joists over four united inches rose by £1 to £12 8s., £13 8s., and £12 8s. respectively. Plates ⅜in. and up were increased £1 to £12 2s. 6d., and boiler plates by £1 to £13 12s. 6d. Black sheets, 24–G. basis for export were advanced £1 7s. 6d. to £17 f.o.b. and galvanised sheets by the same amount to £19 10s. f.o.b. These are fixed prices for British Empire markets and mandated territories and minimum prices for other world markets. In spite of this advance, however, there has been no change in the export situation. Never since the beginning of the war has the position been so tight and export licences so difficult to obtain. This is due, of course, to the excessive home demand, which is absorbing practically the whole of the British iron and steel production. Efforts, however, are being made to allocate more steel for export. The question arises whether it is better to export iron and steel in its usual form, or whether it shall be passed to other industries and exported in a more highly finished state as, for instance, boilers or locomotives. By adopting the latter policy and selling iron and steel in its more expensive form, more relief would be afforded to our exchange position.

The Pig Iron Market

The situation in the pig iron market does not materially alter, and although consumers are inclined to grumble at some of the regulations of the Control, on the whole it is recognised that so far as deliveries are concerned these have prevented a position arising in which some works would have had plenty and other have gone short. The efforts of the producers in all districts are concentrated chiefly upon the production of basic iron, the output of which is at a very high level. In spite of this, however, some consumers are apprehensive as the requirements of the steelworks are so extensive that the whole of the output is passing at once into use. The shortage of scrap leads to an increased demand for pig iron and although efforts are being made to raise the imports of scrap from abroad current requirements are in excess of the present available supply. In the foundry pig iron trade the demand is somewhat irregular. All the output of low phosphoric pig iron is taken up and delivery dates are becoming rather extended. This class of iron is in active request from engineering concerns engaged upon Government contracts and an increase in the supplies would be welcomed by this branch of the consuming industry. By a careful regulation of distribution, however, the Control has been able to maintain deliveries although some firms have supplemented their supplies by purchases of hematite. On the North East Coast the output of foundry iron has been suspended and the makers are concentrating upon the production of basic and hematite iron. The foundries in this district now rely for their supplies upon Midland irons and although their purchases are of a hand to mouth description they are able to obtain their requirements. Many of the Midland light castings foundries are occupied upon Government work, but a considerable number continue to rely upon ordinary commercial business and the majority of those so engaged are working short time. The supplies of high phosphoric pig iron, therefore, which is a description principally used in the light castings section of the industry, are more than sufficient to meet the needs of the consumers. Whilst there is a fair demand for pig iron in Scotland, the light castings industry is poorly employed and is absorbing only small quantities of foundry iron. The situation is so bad that steps are being taken to endeavour to secure more work for the foundries. The hematite market is active and careful supervision is required to maintain an equitable distribution of the available output. Lately there has been some export enquiry, but in view of the heavy home trade demand it has only been possible to satisfy a small percentage. The demand for special grades of hematite from firms engaged upon rearmaments appears to be sharply expanding.

Scotland and the North

With the capacity of the Scottish steelworks pressed to the utmost production is on a huge scale, but so heavy is the demand that it is passing immediately into use. While operations are at such a high level it is only natural that the steelmakers should have their worries with regard to supplies of raw material, but difficulties in this connection have been overcome in a way that would have seemed impossible a year ago. There has been some slackening in the demand for structural steel and joists from the constructional engineers; but this is due rather to seasonal conditions than to any decline in the amount of work on hand. Most of these firms are engaged on big Government jobs and are likely to be fully employed for an indefinite period. Their requirements also will probably expand as the spring progresses. Enormous quantities of steel are also going to the shipyards, which are fully employed. The demand for plates and sections from this source has been an important factor in creating a stringency in the supply position. There is in fact scarcely a section of the iron and steel trades which is not fully employed. The most prominent exception is the light castings makers who as a result of the restrictions upon private building and the consequently poor demand for their products are operating in some cases only two or three days a week. The finished iron trade also, although in contrast to its position a year ago at least comfortably employed, is not working under the same pressure as the steel industry. The re-rolling industry is again beginning to pick up after a short period during which seasonal conditions interrupted transport, whilst at the same time there was a scarcity of billets. The latter has been overcome by a generous distribution of imported material and the works are now in a fair way to overtaking arrears. The demand for small bars, sections and strip is heavy and is taxing the resources of the works. The sheet makers also are engaged upon Government work and are endeavouring at the same time to complete old export orders. Consequently it is not easy to place new business. The export side of the market is practically stagnant since the home demand absorbs every ton of steel which can be obtained. Busy conditions rule in the Lancashire market. The demand for plates of all descriptions is particularly large and consumers have difficulty in finding a works willing to accept orders for anything but far forward delivery. The Lancashire constructional engineers are taking up large quantities of joists and sections and the general engineering works are employed upon Government contracts and are large consumers of special and alloy steels.

The Midlands and South Wales

The steelworks in the Midlands are operating at capacity and are likely to continue to do so for many months. Notwithstanding the huge output of steel which has been maintained there is a tendency for the works to fall into arrears with deliveries, and for this reason many of the steelmakers are reluctant to accept fresh business. Consumers, therefore, are finding conditions difficult, and frequently have to try out the market before they are able to find a works in a position to supply their needs. Orders of special urgency, of course, have to be accepted, but these are only taken when backed by the authorities. Reports are current that the fresh munitions drive has been reflected in new and heavy demands upon the steelworks which have led to alterations in a number of works' programmes. At the same time there has been no relaxation in the pressure exerted by the constructional engineers to obtain supplies of joists and sections. In this department most of the works have fallen into arrears and great efforts are being made to ensure an equitable distribution to consumers. Practically every constructional engineering firm is employed upon big Government contracts and as a consequence there is little likelihood of any decline in the requirements of this branch of the industry. The general engineers are without exception employed full time and their requirements of steel of all descriptions are particularly heavy. The re-rolling works in the Midlands are probably turning out larger tonnages of bars and shapes than at any time in the history of the trade and not only is the whole of this output passing immediately into consumption but it is insufficient to meet the needs of the market. The recent distribution of billets has improved the position in this section so far as raw materials are concerned and most works look forward to an uninterrupted programme. This appears the more likely since it is understood that arrangements have been made to increase the supplies of imported billets and sheet bars. The Midland sheet makers are fully employed principally upon Government orders although the A.R.P. contracts have been largely completed. It is, however, difficult for consumers to place orders for anything but indefinite delivery. Export business is practically at a standstill, and although the quotation for sheets 24–G. basis has been increased by £1 7s. 6d. to £17 f.o.b. the price may be regarded as nominal. In the South Wales market the tinplate trade is in an unusually prosperous condition. The works have about ten and a quarter million boxes of tinplates on their books, and are being pressed to accept fresh orders. The slight decrease in the volume of export business has had little influence upon the general situation since the home trade consumers are clamouring to obtain supplies. The works are concerned with regard to the steel position since the local furnaces although pressing their capacity to the utmost are unable to meet consumers' full demands. Fresh imports of foreign steel, however, should help to ease the position. The heavy steelworks in South Wales are also fully occupied and there is an insatiable demand for the lighter kinds of structural steel.

Copper and Tin

The situation in this country so far as electrolytic copper is concerned has not altered over the week. A short time ago there was talk that the British Government intended to purchase quantities of copper in addition to the tonnages they had contracted for with Empire producers; but these rumours have died down and it is generally believed that there was no substance in them and that no further supplementary quantities will be bought for some time at least. Up to date the amount of copper which the Empire has been able to supply has been sufficient to meet war requirements and although supplies may not be over-abundant there is no shortage. Firms find a difficulty in obtaining metal for ordinary commercial purposes, but this is not surprising in view of the large quantities which are passing into consumption for war work. In the world market prices have shown a tendency to become rather firmer, but it is suggested that this is a temporary movement and that there is a probability that world supplies will expand beyond the needs of consumers. The price of copper in the United States lately has been 11·62½c., equivalent to about £65 2s. 6d., which is not much above the British official maximum price of £62 for electrolytic. A fair amount of business has passed in the United States and some of the neutrals have been active buyers. Most of the business has been transacted in Scandinavian countries and Italy, whilst Russia, also, has been in the market. Some surprise has been occasioned at the amount of copper which some neutrals have taken lately, although in the majority of countries apart from those engaged upon rearmament work business has been poor. . . . In the tin market prices have remained steady although the demand has again become quiet. There is an underlying trace of nervousness in the market and there is considerable discussion as to the probable attitude of the International Tin Committee at its next meeting. The suggestion has been made that the Committee will decide to reduce the present quota of 120 per cent. of the standard tonnage to 100 per cent. or 80 per cent. For the time being supplies in this market seem to be rather abundant, the more so as the lifting of the export prohibition has not been followed by any substantial buying by neutrals. On the other hand, the view is expressed that the quota is not likely to be reduced while the price remains above the £230 limit at which the Buffer Pool can sell, and there is also a probability that the Government might not approve of any movement to reduce supplies unless values drop below £230. Recently an Order was issued by the Board of Trade which brought tin alloys into the licensing system from February 4th, and licences are now required for solder and similar products.

Lead and Spelter

The lead market in Great Britain remains closed and therefore it is difficult to form an accurate judgment of the position. The fact, however, that complaints are rarely heard from consumers regarding deliveries is an indication that so far as supplies are concerned there is little to worry about. Consumption remains at a high level since considerable supplies are being taken by works engaged upon munitions. At the same time it is becoming apparent that the quantities of lead required by this country for military purposes is not so great as in the 1914–18 struggle. In the world market the tendency lately has been for prices to recede, and in many of the neutral countries values are not widely different from the official quotations ruling in this country. Supplies reaching Great Britain are from Empire countries and it is understood that the producers in Mexico are not finding it easy to dispose of their production. It is reported that the increase in the stocks in that country is causing some concern. In the United States the demand is quiet and most of the large consumers appear to have covered their requirements for some time ahead. The producers are understood to be well sold but prices have receded and last week there was a further reduction from 5·25c. to 5c. . . . The spelter position presents no change, supplies are fully maintained and are adequate to meet the calls made by firms engaged upon Government work. The galvanising industry continues to be one of the larger consumers, and as there seems little likelihood of any relaxation in the production of sheets, &c., the demand from this source should continue. In the world market there is only a moderate demand for spelter. It is believed that Germany's domestic production plus the output of the Polish works which have been seized is sufficient for her requirements. In other neutral countries there seems to be no shortage of the metal, although the price varies considerably and the general level is not much above the British official quotation. Quiet conditions are also reported in the United States. In January the production in that country according to the American Zinc Institute was 57,158 short tons compared with 57,941 tons in December. The deliveries in January totalled 57,551 tons against 53,468 tons in the previous month and the stocks at the end of January were 65,602 tons compared with 65,995 tons in December.

CYLINDER SURFACE FINISH.—A number of engineers maintain that the minute surface marks on internal combustion engine cylinder bores should be parallel to the direction of piston motion. A new form of honing tool has been introduced in the United States, by the Micromatic Hone Corporation, which hones a bore in the usual, rotary manner and is then drawn up and down the cylinder to produce a vertical surface finish. The hone consists of a number of interlocked stones axially disposed about a solid backing which is against a cylindrical cone, to provide expansion to the final bore diameter.

THE CREEP OF CONCRETE UNDER LOAD.—The Department of Scientific and Industrial Research has issued a further paper in the series of studies on reinforced concrete, which deals with an investigation at the Building Research Station on the creep or flow of concrete under load. The subject was first considered in Building Research Technical Paper No. 12, published in 1930. Since that time, the scope of the investigation, which originally related to the longitudinal movements resulting from loading in compression, has been widened to include creep in pure tension, lateral movements under compression and the effect of creep on the deformation and ultimate strength of reinforced concrete beams. Some of the test results now published relate to specimens which have been maintained under load for over seven years. Those for Portland cement concretes indicate in all cases that the creep is proceeding at a steadily decreasing rate, and, for each concrete, is tending to a limiting value. Thus the increase in creep from one to five years under load is only about one-fifth of the movement during the first year for specimens loaded at the age of one month. To provide an example of the movements that occur in practice as the result of the shrinkage and creep of concrete, measurements were made periodically for over eight years of the vertical and horizontal deformation of one of the reinforced concrete arches of a large hall in London. An analysis of these measurements is included in the paper.

French Engineering Notes

(From our own Correspondent in Paris)

Civil Production

Official communications affirm that foreign trade is recovering from the effects of the general mobilisation and that since September there has been a steady improvement in exports. The difficulty that confronted manufacturers was the industrial mobilisation which left them with no means of carrying on business unless they were able to undertake armament work. When the armament production settled down the Government began to organise civil production, particularly for export. This was no easy task, for manufacturers had to depend mainly on the State for labour and wholly for raw materials. These supplies were necessarily rationed, with priority for armament work, and manufacturers in different branches of the industry had to constitute themselves into groups for the distribution of iron, steel, and other materials, which were allotted to each group, as far as possible, up to the limit of their requirements. Each consumer receives just the quantity of materials for the execution of orders in hand, without being permitted to lay in stocks. One trouble is a deficiency in the transport of goods, which the railway company is remedying at the expense of passenger traffic. The distribution of materials and export of goods are given priority over the national convenience. Long and tedious formalities to obtain export licences in order to prevent goods from reaching the enemy will doubtless be simplified to the satisfaction of manufacturers by the joint efforts of economic associations specialising in foreign trade and of the Government administrations, which are equally anxious to develop manufacture for export. Makers are encouraged to produce for export by a remission of profit restrictions. Next to armaments, attention is centred on foreign trade, which will be largely extended now that arrangements for providing sufficient labour are well in hand. While, in principle, the whole of the country's engineering resources are to be utilised in some way or another for national defence, it has become obvious that the second line of defence is a growing foreign trade, to which the total production capacity of works not wholly engaged on armament contracts, and others that are not equipped for such work, can make an important contribution. The pooling arrangement with Great Britain gave a start to the foreign trade recovery which is being continued by reciprocal trade agreements with most of the neutral countries. The latest of these agreements is with Spain, which will supply, among other things, iron ore, mercury, and manganese in return for French goods, including a contingent of motor cars. These agreements impose obligations on the French Government that must be fulfilled. The French foreign trade policy is similar to that of the British, and both aim at the creation of a commercial grouping of neutral States that will constitute the groundwork for a new international trade structure.

Evacuation Machinery

Soon after it had taken place, reference was made in these notes to the removal of machinery and plant from the zone in Alsace behind the western front which was immediately threatened by artillery fire and air bombardment. The work had been carefully prepared beforehand, and was carried out with remarkable smoothness and speed. It was some time before the magnitude of that work became known. In three weeks some hundreds of thousands of tons of stocks, machinery, and plant were transferred to the interior of France, where manufacturers installed new works. The motor car works of Mathis and Bugatti were cleared out completely, and everything was dismantled methodically and transported to new sites for immediate re-erection. The material included huge presses for chassis bodies. All this work was accomplished by the military authorities. About thirty factories producing various goods that had been closed down were taken over by the authorities for the manufacture of goods for the army. All other machines were removed, ticketed with the owners' names and sent to central depots. These owners can reclaim them if needed for works installed elsewhere, but if they abandon their manufactures the machines are disposed of to others who require them, in which case owners can claim indemnities.

Minerals in Morocco

At a time like the present when the value of raw material supplies is measured by the convenience and certainty of obtaining them, it is sought to make the fullest use of mineral deposits comparatively close at hand. Since the Bureau de Recherches et de Participations Minières was created by the Protectorate of Morocco in 1928 prospecting has revealed that the country is highly mineralised. Apart from phosphates, which are the leading product of Morocco and are mainly responsible for the development of the port of Casablanca, there has been no considerable exploitation of minerals. This is partly due to lack of transport facilities and, in some cases, to the low grade character of the ore. Iron ore deposits that have been worked during the past three years are not so rich as those of Algeria and Tunis, but they are very extensive, and it is estimated that in the Bou-Ouzal mountain, near Khénifra, there is a reserve of 50 million tons of low grade ore capable of being exploited with open workings. There are large deposits of manganese ore, and it is estimated that when the mining equipment and transport arrangements are completed the annual exports will be about 250,000 tons. Ore containing 12 per cent. cobalt and 5 per cent. nickel is mined on a small scale, and cobalt outcrops are declared to extend along a belt of more than 30 miles in the south of Morocco. Molybdenum is known to exist in many areas, notably in the Atlas range, but only one small mine is at work at present. Lead, zinc, tin, and antimony are worked with the aid of State subsidies. In September last a Direction Générale des Mines was constituted to carry on vigorously the prospection and exploitation of minerals in Morocco with the idea of being assured of reserves for the metallurgical industries. The work of prospecting during the past few years could not be otherwise than incomplete, and there is a strong belief that an impetus now being given to a development of its resources will enable Morocco to supply an appreciable part of the French metal requirements.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

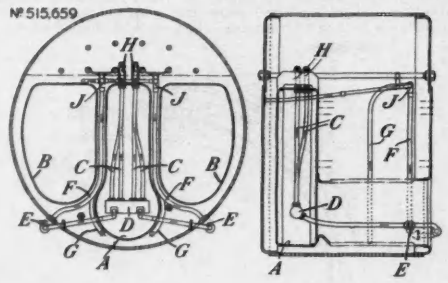
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS

515,659. June 25th, 1938.—PROMOTING WATER CIRCULATION IN STEAM GENERATORS, James MacLeod, 9, Mulberry Road, Newlands, Glasgow.

A steam generator of the Scotch class embodying the invention is illustrated in the accompanying drawings in which the shell of the steam generator is provided with a central combustion chamber A and with two wing combustion chambers B. Within the central combustion chamber are steam generating upcomer tubes C ascending from a common header D at about bridge level within the lower part of the combustion chamber and connected to the bottom of the water space of the generator by way of two pipes led through the interior of the respective furnace, below the level of the grate (not shown), to isolating valves E fitted to the underside of the shell and each communicating with internal pipes F, G. The tubes C connect at their upper ends with conduit elements constituted by ported tubular bolts H fitted to the crown of the combustion

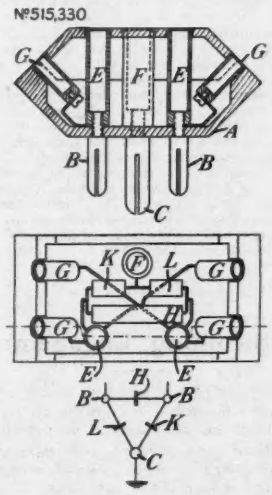


chamber serving as tie-bolts of crown supporting girders. Each of the tubular tie-bolts houses a non-return valve element, is provided with lateral outlet ports below the low water level, and is vented at its upper end to the steam space of the generator. The arrangement and disposition of the tubes are such that they function as steam-generating and water-circulating tubes. Feed water is supplied to the generator through two injector nozzles each housed in a branch-piece J just above the level of the crowns of the combustion chambers, *i.e.*, at the top of the water-space, and interposed between the upper ends of the respective internal pipes F, G of which the pipe G leads water from the bottom of the water space to the branch-piece inlet, and of which the pipe F connects the branch-piece outlet to the respective valve E. Feed water is supplied to the injector nozzles by way of an internal feed pipe led to the nozzles from a check valve (not shown) on the rear end wall of the generator.—*December 11th*, 1939.

ELECTRICAL APPLIANCES

515,330. June 18th, 1938.—ELECTRIC PLUG AND SOCKET COUPLINGS, Dr. Ing. Gunther Subkis (German), of 76, Vivian Avenue, Wembley.

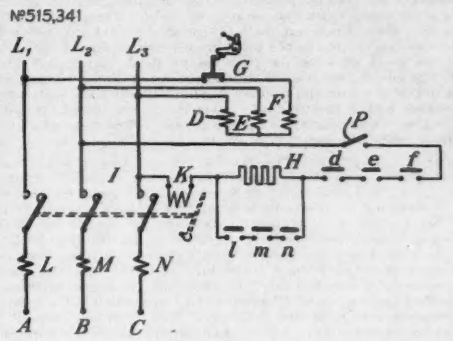
This invention provides a suppressor for eliminating electrical interference in the form of a separate unit which can be plugged into a wall socket or the like as easily as a normal plug and can therefore be used by any person having no electrical knowledge. In the example shown, A is a case preferably of synthetic resinous, or similar insulating material, carrying two



contact pins B and an earth pin C to which are screwed their respective socket ends E and F. Also electrically connected with their respective pins B with or without suitable fuses are the two pairs of sockets G, the whole being held in place by the cover which is of similar material to A and may be secured by screws. The condenser set shown consists of three condensers H and K and L. The condenser H are connected across the two contacts B while K and L are connected across one of the contacts D and the earth pin C respectively.—*December 1st*, 1939.

515,341. June 21st, 1938.—PROTECTIVE SYSTEMS FOR POLYPHASE ELECTRIC CIRCUITS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2, and Sidney Norman Bourne, of Birdingbury, Rugby.

This invention applies to protective systems for electric circuits and more particularly to the protection of three phase circuits against single phase conditions. The operation of the scheme is as follows:—Assuming line contactor 1 has opened and all three incoming lines L1, L2, and L3 are energised, the voltage coils D, E, and F will be energised and close their contacts *d*, *e*, and *f*. If the pilot switch P is now closed there will be a circuit for the operating coil K of line contactor 1 from line L2, through the pilot switch and relay contacts *d*, *e*, and *f*, heater H and coil of contactor 1 to line L3. The contactor will close, and assuming that there is not an open circuit on the motor side of the contactor, current will pass through the relays L, M, and N causing the contacts of these to close and short out the heater H so that the contacts of G remain closed, as the contacts *l*, *m*, and *n* remain closed as long as the current in the lines on the motor side of the contactor is not less than the magnetising current. If, on closing the line contactor, one of the phases on the motor side was open circuited, one of the relays L, M, and N would not close its contacts, and after a predetermined time the current passing through the heater H would cause the contacts G to be latched open. This would

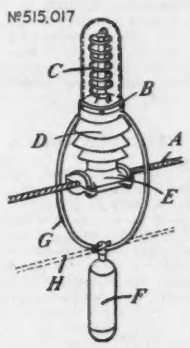


open the circuit of the relay F and its contact *f* which is in series with the operating coil of the line contactor. This would cause the line contactor to open. With the arrangement as shown on the diagram it is intended that the line contactor shall remain open until contacts of the thermal relay G have been reset by hand, or by a remotely controlled coil. If, prior to the closing of contactor 1 there is an open circuit on the line side, which causes either L1, L2, or L3 to be de-energised, one or other of the shunt coil operated relays D, E, or F will not be energised and so will not close its contacts, and the line contactor is therefore prevented from closing. It will be seen, from the above description, that this system of control provides protection against closing the motor on to a single-phase circuit, and also will trip the line contactor and disconnect the motor from the circuit if, when the motor is running, there occurs an open circuit in one of the phases.—*December 1st*, 1939.

TRANSMISSION OF POWER

515,017. *May 20th*, 1938.—NIGHTLY LIGHT BEACONING OF HIGH TENSION OVERHEAD CABLES, Société Anonyme pour les Applications de l'Electricité et des Gaz Rares-Etablissements Claude-Paz and Silva, of 8, Rue Cognacq-Jay, Paris.

This specification describes a device for the nightly light-beaconing of overhead high tension cables, by means of luminescent tubes. The device utilises the known method of feeding a luminescent tube, which consists in connecting one of the high tension cables to one of the electrodes of the tube, the other electrode being connected to an insulated metallic (capacitative) element, the effect of which may be augmented by an auxiliary cable arranged parallel to and at a slight distance from the cable to be lighted. A indicates one of the cables to be lighted. In accordance with the invention the socket B of the luminescent tube C, which latter may for example be in the form of a spiral, is held in position by means of an insulator D attached to the cable A by means of a two-piece metallic sleeve E (or equivalent



member). As regards the capacitative element F this is suspended from the socket B through the intermediary of two curved arms G which encircle the conductor A at a convenient distance. As is known, this element serves the purpose of increasing the capacitative effect to earth of the electrode which is not connected to the conductor A and consequently of ensuring a better feeding of the luminescent tube. It is further known to augment this effect with advantage by means of an auxiliary conductor cable which is disposed parallel to and at a slight distance from the conductor A. Such a conductor H is shown in broken lines, and in case the conductor is too long to be supported by the arms alone, its extremities may be supported by insulators (not shown) suspended from the conductor A. In any case the volume, weight and section of the element F may evidently be so chosen as to ensure perfect mechanical stability of the installation, taking into account the wind-pressure if any.—*November 23rd*, 1939.

BUILDING

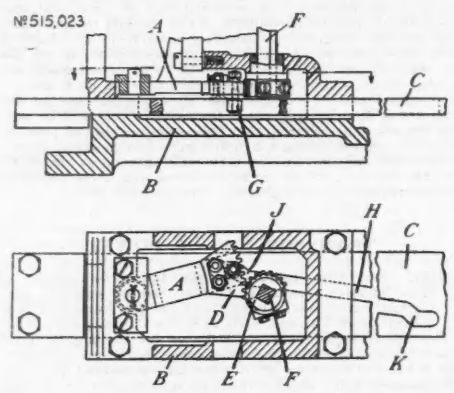
515,120. May 24th, 1938.—FORMING CONCRETE PILES, Alfred Hiley, Dalegarth, Valley Road, Rickmansworth, Hertford, and the British Steel Piling Company, Ltd., Thames House, Millbank, Westminster, S.W.1.

In the formation of concrete piles under soft ground conditions a piling tube, fitted with a shoe, is driven into the ground until a firm resistance is met, after which the tube is supplied with a sufficient quantity of moist concrete to fill the hole up to capping level upon withdrawal of the tube. Should the tube be withdrawn until a very small quantity of concrete remains to be deposited, the pressure at the outlet of the tube is not sufficient to balance the pressure exerted by the soft ground surrounding the free concrete and the ground tends to cave in. Where, however, an additional quantity of concrete has been added to the tube to overcome this difficulty, owing to the high state of lubrication present in the concrete, the surplus concrete does not apply any force beyond its mere dead-weight and is expensive to remove down to the required cap level. This difficulty is overcome according to the present invention

by disposing a bulk of granular material, such as sand with predetermined moisture content, upon the final charge of concrete material previously poured into the tube to compose the pile. Further, the hammer which gives the vibratory movements is so arranged that, for the purpose of depositing the concrete in the softer upper ground, upwardly striking impulses are given to the tube which is allowed to oscillate downwardly between each stroke by the action of gravity further assisted only by the cushioning steam force bringing the hammer to rest at the bottom of its downward stroke so that the sand plug takes its full friction and arching action to grip the tube with full effect. The result is that the concrete is forced to slump downwardly and spread away below the tamping end of the piling tube and thus ram the concrete into a size fully up to a definite and decided area. During the operation of forming the pile sharp upward impulses given to the tube by the piling hammer are caused to act through a pair of extracting links, freeing thereby both the concrete and the sand plug which relaxes its pressure on the tube. Upon removal of pressure the sand plug tends to decrease in volume as the moisture content changes in relation to the voids allowing the plug readily to slip down the tube. On the ensuing downward natural oscillation the sand plug has an opposite action and resumes its substantially fixed stationary position within the tube and develops a pronounced ramming effect to spread out the concrete issuing below the end of the piling tube.—*November 27th*, 1939.

515,023. May 21st, 1938.—RAILWAY POINT AND SIGNAL LEVER MECHANISM, Westinghouse Brake and Signal Company, Ltd., Arthur Greenwood Kershaw and Norman Greenwood Kershaw, all of 82, York Way, King's Cross, London, N.1.

The invention, which has for its object to provide improved arrangements for effecting the operation of the circuit controller, is illustrated by way of example in the accompanying drawings. A short operating lever A is pivotally mounted upon the frame or casing B of the slide bar C, the free end of this lever carrying a toothed gear segment D adapted to intermesh with a corresponding pinion E secured to the shaft F of the rotary element of the circuit controller. A pin G upon the operating lever adjacent to the gear segment projects within the cam slot H formed in the slide bar, this slot being of the usual form comprising sharply inclined end portions J and K connected by an inclined inter-

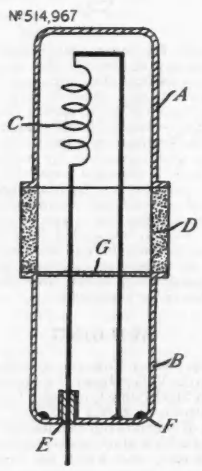


mediate. In operation, the initial movement of the slide bar, when the point or signal lever is operated, causes the sharply inclined end portion J or K of the cam slot to rock the operating lever through a corresponding arc of rotation. This movement of the operating lever is transmitted through the toothed segment and pinion to the rotary shaft of the circuit controller which is accordingly rapidly rotated to effect a corresponding operation of the controller contacts. The continued movement of the point and slide bar causes in a similar manner a further rotation of the circuit controller shaft through an arc of considerable extent and finally a relatively rapid rotation of this shaft to its extreme position as the pin is engaged by the other sharply inclined end portion of the cam slot. The mechanism can be so designed that for the usual slide bar stroke of 8–12in., an arc of rotation of the circuit controller shaft of approximately 150 deg. can be obtained.—*November 23rd*, 1939.

MISCELLANEOUS

514,967. May 19th, 1938.—ELECTRIC DISCHARGE DEVICES, the British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

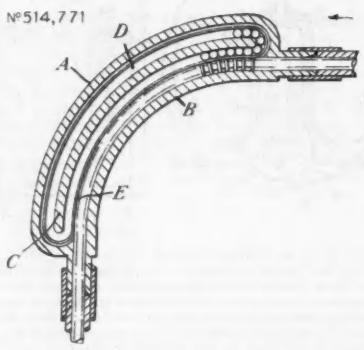
This invention applies to electric discharge vessels with hot or incandescent cathode and a filling of gas or metal vapour in which the discharge vessel itself consists of metal. Such discharge vessels are mostly so made that the wall forms the anode of the discharge vessel and the cathode is introduced insulated. As long as such vessels are operated at a low potential they



work satisfactorily. They are however not suitable for high potentials for the reason that the heat which reaches the metal wall owing to radiation from the incandescent cathode and energy dissipated by the anode imparts to the whole tube a high temperature so that the temperature of the metal supply, *e.g.* of the mercury, determining the vapour pressure, becomes too high. There are also other disadvantages and an object of the invention is to overcome them. The two metal caps of the discharge vessel are indicated by A and B. The cap A represents the anode of the tube and the cap B is conductively connected with the incandescent cathode C projecting into the anode A. The cathode C can be heated directly or indirectly and can in particular be a high output emission cathode of the Hull type. The insulating body D which consists mainly of ceramic material effects the insulation between the cathode and anode caps of the discharge vessel. The small in-lead E for the supply of the heating potential to the cathode is arranged in the cathode part of the discharge vessel and need only be designed for small potentials. The metal supply F (*e.g.*, mercury) is in the part of the discharge vessel connected with the cathode. By means of the heat radiated from the cathode and the energy dissipated by the anode the cap A attains a comparatively high temperature. The low heat conductivity of the insulating body D prevents this heat being transmitted to the cathode cap B. In this way the vapour pressure in the vessel remains relatively low corresponding to the temperature of the cathode cap B so that the vessel is adapted for high potentials. In spite of the comparatively low vapour pressure the anode has a high working temperature which is desirable for technical working reasons, since then no metal vapour is deposited in the anode cap. In order to reduce or to eliminate radiation of heat from the cathode to the cap B there can be provided a perforated heat-protecting screen G in the interior of the discharge vessel.—*May 22nd*, 1939.

514,771. March 3rd, 1938.—FLEXIBLE POWER TRANSMISSION AND REMOTE CONTROL MECHANISM, William Edward Barber, Royal Aircraft Establishment, South Farnborough, Hampshire, and Henry Archibald Watts, Air Ministry, Adastral House, Kingsway, London, W.C.2.

The invention is particularly applicable to power transmission and remote control mechanism described in Patent No. 380,204. When the cable or the like is moved and especially when subjected to compression, there is a tendency for it to be pressed hard against the guiding tube, thereby impeding by friction the movement of the cable. The object of the present invention is to provide a ball or roller device whereby this friction is considerably reduced. According to the embodiment of the invention shown, a device providing a roller bearing to be applied, say, at a bend comprises a long channel-shaped casing A



of rectangular cross-section. In the side B of the casing there is provided a channel of sufficient size to receive the flexible cable and to allow it to move freely therein. The two ends of the casing are closed except for tubular extensions through which the cable passes. Midway between the inner surfaces of the casing is a dividing wall C providing a closed channel D. Arranged within this channel so as to fill it are rollers. Interposed between the rollers and the cable there is one portion of an endless flexible band of steel, extending around the whole length of the channel. This flexible band serves to provide a smooth surface against which the flexible cable can bear. If the flexible cable is placed under compression to transmit movement it presses on the flexible band, but a braking effect is not produced as the band can move with it on the rollers which can also move in the channel.—*November 17th*, 1939.

514,552. March 28th, 1938.—IMPROVEMENTS IN EXCAVATING MACHINES, Harry Fairclough, Howley, near Warrington, and Ruston-Bucyrus, Ltd., Excavator Works, Lincoln.

In excavating machines particularly those of the back acting or drag shovel type scoops for digging narrow trenches are of uniform rectangular cross-section throughout their length and of comparatively considerable depth. In excavating material of a sticky or clay-like nature it is very difficult to discharge the contents under the action of gravity when the scoop has been swung into the dumping position. The object of the invention is to provide an improved form of scoop, more particularly for digging narrow trenches, which will permit dumping to be effected without the use of an ejector. The scoop described is of comparatively shallow depth, and preferably of elongated form, so that when excavating in sticky or clay-like material there will be a tendency for the latter to bank up above the side edges or the side walls of the scoop from the front edge to the rear. Owing to the reduced surface area in contact with the material, the frictional resistance to movement under the action of gravity when the scoop is swung into the dumping position, will be correspondingly reduced. This permits the total weight of the banked up mass of agglomerated material to overcome the reduced resistance, and readily fall or slide from the scoop more or less solidly.—*November 13th*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Chemical Engineering Group

To-day, Feb. 16th.—Chemical Society's Rooms, Burlington House, Piccadilly, W.1. "The Chemical Plant Manufacturer in Relation to Chemical Industry," B. N. Reavell and G. E. Foxwell. 2.30 p.m.

Thursday, Feb. 29th.—Neville Hall, Newcastle-upon-Tyne. "Modern Gas Storage," S. Thomson.

Institute of Fuel

Thursday, Feb. 22nd.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "Modern Gas Storage," S. Thomson. 2.15 p.m.

Institution of Automobile Engineers

Monday, Feb. 19th.—Glasgow Centre. Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow. "The Use of Gas as a Fuel for Motor Vehicles," J. S. Clarke. 7.30 p.m.

Wednesday, Feb. 21st.—Leeds Centre. Hotel Metropole, Leeds. "Some Problems We Meet," L. H. Dawtrey. 6 p.m.

Institution of Civil Engineers

Tuesday, Feb. 20th.—Great George Street, Westminster, S.W.1 "The Dragline Excavator," W. Barnes. 5.30 p.m.

Wednesday, Feb. 21st.—N. W. Assoc. 36, George Street, Manchester. "The Uses of Gunite," T. Whitley Moran. 6. 15 p.m.

Institution of Electrical Engineers

Thursday, Feb. 22nd.—Savoy Place, Victoria Embankment, W.C.2. "Insulation Stresses in Transformers, with special reference to Surges and Electrostatic Shielding," H. L. Thomas. 6 p.m.

Saturday, Feb. 17th.—N. Midland Centre. Hotel Metropole, Leeds. "Operating Experience with High-Voltage Alternators, W. D. Horsley. 2 p.m.

Institution of Engineers-in-Charge

Wednesday, Feb. 21st.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, Strand, W.C.2. "Modern Lighting Practice and Progress, with Special Reference to A.R.P. Requirements," R. Pelerin. 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, Feb. 20th.—39, Elmbank Crescent, Glasgow. "Welding as a Substitute for Casting," S. F. Dorey. 6.30 p.m.

Institution of Locomotive Engineers

Wednesday, Feb. 28th.—Savoy Hotel, W.C.2. Annual Dinner 6.30 for 7 p.m.

Institution of Mechanical Engineers

To-day, Feb. 16th.—Storey's Gate, Westminster, S.W.1. Annual General Meeting. Presidential Address "The Influence of the Mechanical Mind on the Development of Irrigation throughout the Ages," E. Bruce Ball. 2.30 p.m.

Saturday, Feb. 17th.—Yorkshire Branch. The University, St. George's Square, Sheffield. "A Review of Forty Years' Development in Mechanical Engineering Plant for Power Stations," Sir Leonard Pearce. 2.30 p.m.

Friday, March 1st.—Storey's Gate, Westminster, S.W.1. "The Circulation of Water and Steam in Water-Tube Boilers, and the Rational Simplification of Boiler Design," W. Yorath Lewis and S. A. Robertson. 6 p.m.

Institution of Production Engineers

Tuesday, Feb. 20th.—Mostyn Hotel, Portman Square, W.1. "Modern Instruments of Measurement and the Principles of their Design," G. Schlesinger. 7.30 p.m.—Eastern Counties Section. Public Library, Ipswich. "Conveying Systems as Applied to Present Day Production Methods," A. Clarke. 7.30 p.m.

Tuesday, Feb. 20th.—Luton Section. Queen's Engineering Works, Bedford. "Time Measuring Installations," J. S. Godman. 7.30 p.m.

Wednesday, Feb. 21st.—Birmingham Section. James Watt Memorial Institute, Great Charles Street, Birmingham. "Psychology of Accident Causation," C. A. Oakley, 7 p.m.

Thursday, Feb. 22nd.—Leicester Section. College of Technology, The Newarke, Leicester. "Measuring Methods," J. E. Sears. 7.30 p.m.

Saturday, Feb. 24th.—Yorks. Section. Hotel Metropole, Leeds. "Some New Applications of Optics to Engineering," M. H. Taylor. 2.30 p.m.

Junior Institution of Engineers

Saturday, Feb. 17th.—Midland Section. James Watt Institute, Great Charles Street, Birmingham. "Practical Applications of Temperature Control and Measurement," W. M. Barratt. 2.30 p.m.

Monday, Feb. 19th.—N. W. Section. Engineers' Club, Albert Square, Manchester. Chairman's Address, G. L. Wollaston. 7.30 p.m.

Friday, Feb. 23rd.—39, Victoria Street, S.W.1. "The Application of Steam Propulsion to Road Vehicles," M. Harman Lewis. 6.30 p.m.

Manchester Association of Engineers

Friday, Feb. 23rd.—Engineers' Club, Albert Square, Manchester. "Development in Design of Boilers and Boiler House Auxiliaries," A. Pollitt. 7.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Feb. 16th.—Student Section. Bolbec Hall, Newcastle-upon-Tyne. "Electrical Measurement of Mechanical Quantities," W. W. Campbell. 6.45 p.m.

Thursday, Feb. 22nd.—Mining Institute, Newcastle-upon-Tyne. "Creep at High Temperatures," H. L. Tapsell. 6 p.m.

Royal Aeronautical Society

Tuesday, March 12th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Aircraft Production," H. J. Pollard. 6 p.m.

Royal Institution of Great Britain

To-day, Feb. 16th.—21, Albemarle Street, W.1. "Physics in War Time," Sir W. Bragg. 5 p.m.

Sheffield Society of Engineers and Metallurgists, Sheffield Metallurgical Association, Iron and Steel Institute

Tuesday, Feb. 20th.—Grand Hotel, Sheffield. "Oxygen Determinations on a Series of Bath Samples taken from an Acid Open Hearth Furnace." G. E. A. Bramley and G. Tateson. "Tensional Effects of Torsional Overstrain in Mild Steel," Prof. H. W. Swift. "A study of a Nickel Chromium-Molybdenum-Vanadium Steel Ingot." Dr. W. H. Hatfield. 7.30 p.m.

Wolverhampton and District Engineering Society

Tuesday, Feb. 20th.—Victoria Hotel, Wolverhampton. "Mechanical Failures and Breakdowns," D. Llewellyn. 7.30 p.m.

CATALOGUES

PATENT RETORTS, Ltd., 5, Victoria Street, S.W.1. Pamphlet on the T.M.D. furnace grate.

SOLIGNUM, Ltd., 205, Borough High Street, London, S.E.1. Booklet on A.R.P. camouflage and protective paint.

DAVIDSON AND CO., Ltd., Belfast. Publication S.F. 300 on "Sirocco" products for dust removal and collection.

T. H. and J. DANIELS, Ltd., Lightpill Ironworks, Stroud, Glos. Illustrated List D 39/12 of plant for rubber.

HYLAND, Ltd., Doncaster Road, Wakefield. Catalogue of "Hyland" hydraulic deck machinery for steam and motor ships.

PETER BROTHERHOOD, Ltd., Amberley House, Norfolk Street, London, W.C.2. Publication illustrating and describing steam turbines.

BRITISH TIMKEN, Ltd., Cheston Road, Aston, Birmingham. Catalogue describing the application of "Timken" tapered roller bearings to machine tools.

BENNIE LIFTS, Ltd., 2, Tinworth Street, Albert Embankment, London, S.E.11. Leaflet describing the Crighton mechanical roof shutters for light obscuration.